Human Capital, Bankruptcy and Capital Structure*

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ABSTRACT

In an economy with perfectly competitive capital and labor markets, we derive the optimal labor contract for firms with both equity and debt, and show that it implies employees will become entrenched and therefore face large human costs of bankruptcy. The firm's optimal capital structure emerges from a trade-off between these human costs and the tax benefits of debt. Our model delivers optimal debt levels consistent with those observed in practice without relying on frictions such as moral hazard or asymmetric information. In line with existing empirical evidence, our model implies persistent idiosyncratic differences in leverage across firms, and shows that wages should have explanatory power for firm leverage.

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Ever since Modigliani and Miller (1958) first showed that capital structure is irrelevant in a frictionless economy, financial economists have puzzled over exactly what frictions make the capital structure decision so important in reality. Over the years a consensus has emerged that at least two frictions are important: corporate income taxes and bankruptcy costs.

An interesting characteristic of capital structure research is the apparent disconnect between the costs of bankruptcy identified in the academic literature and those discussed in the popular press. During a corporate bankruptcy, the press almost invariably focuses on the *human* costs of bankruptcy. This focus can be explained by research in psychology that demonstrates that job security is one of the most important determinants of human happiness and that the detrimental effect on happiness of an involuntary job loss is significant.[1] Yet these human costs of bankruptcy have received minimal attention in the corporate finance literature. It is not difficult to understand why. Intuitively, if employees are being paid their competitive wage, it should not be very costly to find a new job at the same wage. Thus, for substantial human costs of bankruptcy to exist, employees must be entrenched; they must incur costs associated either with not being able to find an alternative job, or with taking another job at substantially lower pay. However, such entrenchment seems difficult to reconcile with optimizing behavior: Why do shareholders overpay their employees, especially at times when the firm is facing the prospect of bankruptcy?[2]

In this paper we argue that this intuition is wrong. In fact, entrenchment is an optimal response to labor market competition. In an economy with perfectly competitive capital and labor markets, one should *expect* employees to face large human costs of bankruptcy. Moreover, consistent with anecdotal evidence, these indirect costs of bankruptcy are large enough to impose significant limits on the use of corporate debt.

Our results extend the insights of Harris and Holmström (1982). In a setting without bankruptcy, debt or limited liability equity, that paper shows that the optimal employment contract between a risk-averse worker and a risk-neutral equity holder guarantees job security (employees are never fired), and pays employees a fixed wage that never goes down but rises in response to good news about employee ability. The intuition behind this result is that while employees are averse to their own human capital risk, this risk is idiosyncratic so

[1]Helliwell (2003) finds that, of the events he studies, the loss of a job is only outranked by a marriage separation in its detrimental effect on happiness. Job loss ranked equal to a significant drop in health and even outranked the death of a spouse. Similarly, Di Tella, MacCulloch, and Oswald (2001) finds that a 1% increase in the unemployment rate decreases overall happiness 66% more than a 1% increase in the inflation rate. Layard (2005) provides a comprehensive review of the research on happiness.

[2]Firm-specific human capital is one possible explanation (see Neal (1995)). Yet, in an efficient labor market, it is not clear that employees are necessarily paid for their investments in human capital. Even if they are, in a competitive economy like the United States it is hard to argue that most employees' skills are not easily transferable, or that wages could not be lowered during financial distress.

equity holders can costlessly diversify it away. Optimal risk sharing then implies that the shareholders will bear all of this risk by offering employees a fixed wage contract; however, employees cannot be forced to work under such a contract because employees who turn out to be better than expected will threaten to quit unless they get a pay raise. This threat leads to the optimal contract derived by Harris and Holmström (1982).[3]

Our first contribution is to derive the optimal compensation contract in a setting that includes both (limited liability) equity and debt. We find that the optimal employment contract in this setting is similar to that in Harris and Holmström (1982): Unless the firm is in financial distress, wages never fall, and they rise in response to good news about employee productivity; however, unlike Harris and Holmström (1982), if the firm cannot make interest payments at the contracted wage level, the employee takes a *temporary* pay cut to ensure full payment of the debt. If the financial health of the firm improves, wages return to their contracted level.[4]

If the firm deteriorates further, so that it cannot make interest payments even with wage concessions, it is forced into bankruptcy. In bankruptcy, it can abrogate its contracts, and employees can be terminated and replaced with more productive employees. Because contracted wages never fall in response to bad news about employee productivity, employees' wages at the moment of termination will typically be substantially greater than their competitive market wages. As a result, these entrenched employees face substantial costs resulting from a bankruptcy filing; they will be forced to take a wage cut and earn their current market wage.

Our second contribution is to derive the implications of this optimal employment contract for the firm's capital structure. The amount of risk sharing between investors and employees depends on the level of debt. Higher debt levels imply a higher probability of bankruptcy or financial distress (states in which the risk-averse employees receive lower wages), and hence less risk sharing. Using this insight, we derive a theory of optimal capital structure by introducing the second important friction identified in the literature, the corporate tax

[3]Several other papers in labor economics have studied optimal wages when the firm is risk neutral but the workers are risk-averse. See, for example, Holmström (1983), Bester (1983), or Thomas and Worrall (1988).

[4]There are numerous examples of temporary pay cuts incurred by employees of firms in financial distress. For example, at AIG, the Chief Executive's pay was cut to $1 in the fall of 2008 and the firm paid no bonuses in 2008 to its top employees (see "AIG praised for freezing the salaries of seven executives," by Greg Farrell, Financial Times, November 26th 2008, `http://www.ft.com/cms/s/0/1fa2351c-bb5c-11dd-bc6c-0000779fd18c.html`). Morgan Stanley CEO, John Mack, forwent his 2007 bonus after a large loss in the fourth quarter of 2007 (see "Morgan Stanley and Merrill chiefs forgo bonuses," by Gregg Farrell and Francesco Guerrera, Financial Times, December 9th 2008, `http://www.ft.com/cms/s/0/abd4c69a-c55b-11dd-b516-000077b07658.html`), and Goldman Sachs paid no bonus for 2008 to its top seven executives (see "No Bonuses for 7 Senior Executives at Goldman," by Ben White, New York Times, November 16, 2008, `http://www.nytimes.com/2008/11/17/business/economy/17goldman.html`)

shield. In our model firms trade off the benefits of risk sharing against the benefits of tax shields, and we show that this model has the potential to resolve some of the apparent puzzles identified in the data. For example, even in the presence of potentially large tax shields, firms optimally issue only modest levels of debt, and in fact, in some cases, will maintain cash balances despite the associated tax disadvantages.

Our model identifies a number of determinants of the cross-sectional distribution of firm leverage that have not previously been investigated. Perhaps most intriguing, given the empirical evidence, is our result that firms' capital structure decisions should be influenced by effects idiosyncratic to the firm. In our model, the capital structure decision trades off the employees' risk aversion against the benefits of debt. Thus, if the degree of risk aversion differs across employees at different firms, it is optimal even for otherwise similar firms to choose different leverage policies. Firms with low leverage will be attractive for employees with relatively high risk aversion, whereas employees with low risk aversion will be attracted towards firms with high leverage. This effect will thus be self-reinforcing. Ultimately, heterogeneity in risk aversion in the labor market should result in a clientele effect, implying persistent heterogeneity in the average risk aversion of employees and in capital structure choices amongst otherwise identical firms. Our model may thus help to explain the persistent heterogeneity in firms' capital structures documented in Lemmon, Roberts, and Zender (2008), which has puzzled financial economists. Interesting empirical support for the presence of clientele effects among corporate CEOs is provided in a recent paper by Graham, Harvey, and Puri (2008). They document a strong relation between CEO risk aversion and corporate characteristics such as growth or merger activity. Consistent with our model's predictions, they also find a negative (although not statistically significant) relation between CEO risk aversion and leverage.

We make several other predictions about the cross-sectional distribution of leverage. In our model, employees pay for the insurance provided by the labor contract by accepting lower wages. Ceteris paribus, higher leverage should therefore be associated with higher wages. Motivated by this insight, Chemmanur, Cheng, and Zhang (2008) look for and find empirical evidence of a positive relation between wages and leverage. With the additional assumption that capital is less risky than labor, our model also predicts that more labor-intensive firms should have lower leverage. In addition, because capital-intensive firms tend to be larger, a cross-sectional relation between debt levels and firm size should exist; large firms should be more highly levered. This prediction is supported by the existing empirical evidence. Titman and Wessels (1988), Rajan and Zingales (1995) and Fama and French (2002) all document a positive cross-sectional relation between leverage and firm size. Finally, a positive relation between firm size and wages should also exist. Interestingly, this cross-sectional relation has been documented empirically, and is regarded as an unexplained puzzle by labor economists (see Brown and Medoff (1989)).[5]

The rest of the paper is organized as follows. Section 1 places our paper within the existing literature. Section 2 describes the model and derives the optimal labor contract in our setting. Section 3 derives empirical implications of the optimal contract for the firm's capital structure. We then parametrize the model and illustrate its implications. Section 5 discusses a number of existing studies that bear directly on the implications of the model. Section 6 concludes the paper.

1 The Setting

Our paper adds to the literature that tries to understand firms' capital structure decisions as a response to market frictions such as bankruptcy costs and taxes. Researchers have long struggled to identify specific bankruptcy costs large enough to offset the benefits of debt. Andrade and Kaplan (1998) and Graham (2000) persuasively argue that the observed size of bankruptcy costs are inconsistent with observed leverage. In response, Almeida and Philippon (2007) argue that empirical estimates may underestimate the relevance of bankruptcy costs, due to risk premia; however, Haugen and Senbet (1978) argue that any bankruptcy costs that directly accrue to debt or equity holders cannot exceed the cost of renegotiating to avoid bankruptcy altogether (otherwise debt holders would have an incentive to avoid the costs by recapitalizing the firm outside bankruptcy). This significantly limits the role of direct bankruptcy costs. In response, Titman (1984) points out that stakeholders not represented at the bankruptcy bargaining table (such as customers and suppliers), can also suffer material costs resulting from the bankruptcy. Because the claimants at the bargaining table (the debt and equity holders) do not incur these costs, they have no incentive to negotiate around them, so such indirect bankruptcy costs are not limited by the Haugen and Senbet (1978) critique. The human cost we study in this paper is an example of an indirect bankruptcy cost, which we argue is large enough to offset the benefits of debt.

Our focus on the human cost of bankruptcy is closely related to the literature that examines capital structure decisions in the presence of management entrenchment. Novaes and Zingales (1995), Zwiebel (1996), Subramanian (2002) and Morellec (2004) provide formal

[5] Our paper is related to the literature in labor economics that focuses on the risk-sharing role of the firm. Gamber (1988) considers bankruptcy in a setting similar to Harris and Holmström's, and derives as an implication that real wages should respond more to permanent shocks than temporary shocks. He also finds empirical support for this prediction. More recently, Guiso, Pistaferri, and Schivardi (2005) test this implication using firm-level wage data. They also find strong support for the risk-sharing role of the firm. Our paper adds to this literature by deriving another testable implication — leverage and wages should be inversely related.

models of a manager's capital structure choice when ownership is separated from control and managers are entrenched for exogenous reasons. In these papers, entrenched managers determine the firm's capital structure, recognizing that they can be fired (and thus take a utility loss) if the firm goes bankrupt (or is taken over). Because employees are entrenched, capital structure decisions reflect this desire to avoid being replaced. These papers do not explicitly consider the effects of a competitive labor market and so do not provide an endogenous reason for entrenchment. In contrast, we derive managerial entrenchment endogenously as an optimal response to labor market competition. The capital structure implications of this optimal response are the opposite of those of the existing entrenchment literature. In particular, debt is costly in our model, whereas it is beneficial in the models cited above because there it mitigates the inefficiencies that result from entrenchment. There is no inefficiency associated with entrenchment in our model; our only friction is the inability of employees to insure their human capital, which is not a focus of the prior literature on entrenchment and capital structure. In our model, entrenchment is the efficient response to this friction rather than an exogenously imposed inefficiency.

Several papers have analyzed the interaction between capital structure choice and the firm's employees' compensation and incentives. Our paper shares a key insight with both Chang (1992) and Chang (1993), namely, that bankruptcy triggers recontracting. Although this recontracting is value-enhancing ex post in both models, it represents an ex-ante cost of debt in our model (because it reduces risk sharing) but an ex-ante benefit in Chang's models (because it allows managers to precommit). Chang (1992) and Chang (1993) therefore identify new benefits of debt that reinforce its tax advantages. In contrast, our model identifies a disadvantage of debt that can serve to counterbalance these tax advantages.

Butt-Jaggia and Thakor (1994) is the most closely related paper to ours. In both papers, debt is costly because it limits the firm's ability to write long term labor contracts (which do not survive bankruptcy). However, the applications are different. Butt-Jaggia and Thakor (1994) analyze the decision of an employee to invest in firm-specific human capital. Employees optimally choose to invest less when a firm faces a higher probability of bankruptcy, causing firms to limit their use of debt. Our paper significantly increases the scope of this insight by focusing on optimal compensation even in the absence of firm specific human capital. We show that the insight in Butt-Jaggia and Thakor (1994) that, because of human capital concerns, firms might limit their use of debt, applies much more generally.

The finance literature has also identified other reasons to limit the use of debt, which are not related to bankruptcy costs. Most of these alternative explanations rely on asymmetric information and moral hazard, such as debt overhang and risk shifting.[6] In contrast to

[6]See, for example, Myers (1977); Jensen and Meckling (1976) Sundaresan and Wang (2008); Mauer and

these models, we analyze the role of capital structure without relying on moral hazard or asymmetric information and solve for the optimal employees' compensation under fairly mild contracting restrictions.

2 Optimal Labor Contract

In this section, we derive the optimal contract for a risk-averse employee working for a firm with risk-neutral investors. We extend the results of Harris and Holmström (1982) by allowing for debt, limited liability equity and bankruptcy.[7]

The economy contains a large number of identical firms, each of which begins life at time 0 and lasts forever. Firms require two inputs to operate: capital in the amount K, and an employee who is paid a competitive wage c_t and produces, at time t, the fully observable (and contractible) cash flow, $K\,R + \phi_t$. R is the pretax return on capital, which we assume to be constant, and ϕ_t is the fully observable stochastic productivity of the employee. Firms make their capital structure decision once, at time 0, raising the required capital by issuing debt, D, and equity, $K - D \geq 0$. The firm must pay corporate taxes at rate τ on earnings after interest expense, so the debt generates a tax shield of τ per dollar of interest paid.[8]

We assume that capital markets are perfectly competitive. The only source of risk in the model is volatility in the employee's output, which we assume is idiosyncratic to the employee and thus to the firm. Investors can diversify this risk away, so the expected return on all invested capital is the risk-free rate, r. There are no personal taxes, capital investment is irreversible, and there is no depreciation. In addition, we assume for simplicity that the pre-tax return on capital is $R \equiv \frac{r}{1-\tau}$.

Bankruptcy occurs at the stopping time T when the employee is so unproductive that the firm cannot meet its cash flow obligations. At that point, we assume all contracts can be unilaterally abrogated, so the firm is no longer bound by the employee's labor contract and can, instead, enter the competitive labor market and hire a new employee, who will immediately put the capital to productive use. Because there are no direct costs of bankruptcy, the firm is then restored to its initial state (and hence its initial value) and can thus meet

Triantis (1994); Morellec and Schürhoff (2008); Morellec and Smith (2007); Hennessy (2008).

[7] In principle, there is no reason why the optimal equity contract requires limited liability. However, such contracts would be very difficult to trade in anonymous markets. Without the ability to trade, equity holders would no longer be able to diversify costlessly, and so the underlying assumption that they are not averse to human capital risk would be difficult to support. Hence, allowing for limited liability equity is important.

[8] Although we focus on taxes, other advantages of debt examined in the literature include the unobservability of cash flows (see Townsend (1979) and Gale and Hellwig (1985)) or the inability of an entrepreneur to commit human capital to the firm (see Hart and Moore (1994)).

its interest obligations.[9] The firm's debt is therefore riskless (and perpetual), with a coupon rate equal to r.

A bankruptcy filing therefore creates value in our model. For simplicity, we assume that equity holders are able to hold onto their equity stake and hence capture this value. The assumption that equity holders remain in control reflects the reality of Chapter 11 bankruptcy protection in the U.S.,[10] but most of the results in this paper would remain valid even if debt holders were to capture some or all of this value.

To focus on the effect of risk sharing, we make a number of simplifying but restrictive assumptions. Because of our assumption that the firm can unilaterally abrogate all contracts in bankruptcy, it will not make payments after a bankruptcy filing to any fired employee. The firm thus cannot commit to severance payments, or to a corporate pension, after a bankruptcy filing. We also assume that a firm cannot make severance payments to a fired employee prior to bankruptcy. Following Harris and Holmström (1982), we also assume that employees are constrained to consume their wages. They cannot borrow or lend. As Harris and Holmström explain, if employees could borrow *without an option to declare personal bankruptcy*, the first best contract where the employee earns a fixed wage forever is achievable, so as in Harris and Holmström (1982) this constraint is binding. However, unlike Harris and Holmström (1982), in our setting the savings constraint is also binding, because employees have an incentive to save to partially mitigate the effects of a bankruptcy filing.

There is a large, but finite, supply of employees with time separable expected utility and a rate of time preference equal to the risk free rate: $E_t\left[\int_t^\infty \beta^s u(c_s)\,ds\right]$, where $u'(\cdot) > 0$, $u''(\cdot) < 0$, and $\beta \equiv e^{-r}$. Employees can only earn wage-based compensation — they cannot be paid in the form of securities issued by the firm — but, because we place no restriction on the form of the wage contract, it includes the possibility of a contract that matches the payoff on any corporate security prior to bankruptcy. The important restriction this assumption imposes is that it rules out compensation contracts that *survive* bankruptcy. For example, we do not allow employees to be paid with corporate debt.

The firm produces after tax cash flows at time t of $(\frac{Kr}{1-\tau} - Dr + \phi_t - c_t)(1-\tau) + Dr$. Of this, Dr is paid out as interest on debt and the rest is paid out as a dividend, δ_t, given by

$$\delta_t = Kr - Dr(1-\tau) + (\phi_t - c_t)(1-\tau). \tag{1}$$

Because the capital market is competitive, the market value of equity at time t, V_t, is the

[9] If the capital investment were partially reversible, so could be sold to pay off debt, the point of bankruptcy would be delayed but not eliminated. The qualitative implications of the model would remain the same, but the model would be greatly complicated because the level of capital would enter as a second state variable.

[10] Equity holders can maintain control even in countries without Chapter 11 protection (see Strömberg (2000)).

present value of all future dividends,

$$
\begin{aligned}
V_t &= E_t\left[\int_t^T \beta^{s-t}\delta_s\,ds + \beta^{T-t}V_T\right],\\
&= E_t\left[\int_t^T \beta^{s-t}\left((K-D)r + (\phi_s - c_s)(1-\tau) + Dr\tau\right)\,ds + \beta^{T-t}V_T\right]\\
&= E_t\Big[(K-D)\left(1-\beta^{T-t}\right) + \beta^{T-t}V_0 + \\
&\qquad \int_t^T \beta^{s-t}\left((\phi_s - c_s)(1-\tau) + Dr\tau\right)\,ds\Big], \qquad (2)
\end{aligned}
$$

where $V_T = V_0$ because, at the point of bankruptcy, the firm is restored to its initial state. The initial value of equity must equal the value of the capital supplied, $V_0 = K - D$, so

$$
V_t = K - D + E_t\left[\int_t^T \beta^{s-t}\left((\phi_s - c_s)(1-\tau) + Dr\tau\right)\,ds\right]. \qquad (3)
$$

Thus, at time 0, we have

$$
E_0\left[\int_0^T \beta^t((\phi_t - c_t)(1-\tau) + Dr\tau)\,dt\right] = 0. \qquad (4)
$$

Firms compete to hire employees of a given ability in a competitive labor market. As a result, the firm cannot pay the employee less than his market wage (the wage he would earn were he newly hired by an identical firm), because otherwise he would quit and work for that firm. So at any subsequent date, ν, the value of equity cannot exceed its time 0 value, $V_\nu \leq V_0$, because otherwise the employee would be making less than his market wage. Hence,

$$
E_\nu\left[\int_\nu^T \beta^{t-\nu}((\phi_t - c_t)(1-\tau) + Dr\tau)\,dt\right] \leq 0, \qquad \forall \nu \in [0, T]. \qquad (5)
$$

Prior to bankruptcy, the firm must be able to meet its interest obligations. Thus, because the dividend received by shareholders is never negative, the employee's wages cannot exceed the total cash generated by the firm less the amount required to service the debt, i.e.

$$
c_t \leq \phi_t + r\left[\frac{K}{1-\tau} - D\right]. \qquad (6)
$$

For now we assume that bankruptcy occurs when the firm cannot make interest payments even when the employee gives up all of her wages, that is, when

$$
Kr + \phi(1-\tau) - Dr(1-\tau) = 0, \qquad (7)
$$

or equivalently, when

$$\phi_t = \underline{\phi} \equiv \left[D - \frac{K}{1-\tau} \right] r. \tag{8}$$

so

$$T \equiv \min \left\{ t \,\middle|\, \phi_t < \underline{\phi} \right\}.$$

In principle, the employee could force bankruptcy to occur earlier by not giving up all her wages, but we shall show later that this is not optimal.

To derive the optimal labor contract, we maximize the employee's expected utility subject to the above constraints that the firm operates in a competitive capital and labor market (i.e., (4)–(6)) and that consumption is non-negative:[11]

$$\max_c E_0 \left[\int_0^T \beta^t u(c_t)\, dt \right] \tag{9}$$

$$\text{s.t.} \quad E_0 \left[\int_0^T \beta^t ((\phi_t - c_t)(1-\tau) + Dr\tau)\, dt \right] = 0, \tag{10}$$

$$E_\nu \left[\int_\nu^T \beta^{t-\nu} ((\phi_t - c_t)(1-\tau) + Dr\tau)\, dt \right] \leq 0, \quad \forall \nu \in [0,T], \tag{11}$$

$$(c_t - \phi_t)(1-\tau) - r\left[K - D(1-\tau)\right] \leq 0, \quad \forall t \in [0,T], \tag{12}$$

$$c_t \geq 0, \quad \forall t \in [0,T]. \tag{13}$$

Note that, while the first two constraints are similar to those in Harris and Holmström (1982), the third, reflecting equityholders' limited liability and the presence of debt, is new. We now show that the optimal contract is an extension of that in Harris and Holmström (1982). First define the *market wage contract*:

Definition 1 *The market wage contract initiated at time t is a contract, together with an associated market wage function, $c^*(\phi, t)$, under which an employee, hired at date t, is paid at any date $s \in [t, T]$ the amount*

$$c^*_{t,s} = \min \left\{ \phi_s + r\left[\frac{K}{1-\tau} - D \right], \max_{t \leq \nu \leq s} \left\{ c^*(\phi_\nu, \nu) \right\} \right\}, \tag{14}$$

where the function $c^*(\phi_\nu, \nu)$ is chosen to ensure that the employee's pay satisfies

$$E_\nu \left[\int_\nu^T \beta^{s-\nu} ((\phi_s - c^*_{\nu,s})(1-\tau) + Dr\tau)\, ds \right] = 0, \tag{15}$$

for all $\nu \in [t, T]$.

[11] Because the bankruptcy date does not depend on the choice of contract, the contract that maximizes utility until bankruptcy also maximizes lifetime utility.

At date s, define the *promised wage* to be $\overline{c}_s \equiv \max_{t \le \nu \le s}\{c^*(\phi_\nu, \nu)\}$, and the *financial distress wage* to be $\phi_s + r\left[\frac{K}{1-\tau} - D\right]$. Lemma 2 in the appendix shows that the initial wage paid under this contract is always equal to the promised wage. However, after the initial date the employee does not always receive the promised wage because the firm may not have enough cash left over after making its debt payments. In these states, which we term financial distress, the employee takes a temporary pay cut, receiving whatever cash remains after debt payments have been made (the financial distress wage), so that the firm can meet its interest obligations and avoid bankruptcy. Note that the promised wage never falls, but rises when necessary to match the wage available to the employee in the labor market were he to quit and work for an identical firm. This wage is also the wage a newly hired employee with the same ability level would earn at the current firm.

For some ability levels, $c^*(\phi, t)$ might not be positive. For example, for very low levels of ϕ, it may be impossible to pay the employee any positive amount and still satisfy Equation (15). Note, however, that by the definition of the market wage and the point of bankruptcy, if the initial wage is positive, then all future wages prior to bankruptcy will be positive: $c^*(\phi_t, t) > 0$ then $c_s > 0$ for any $s \in [t, T)$.

Define a *feasible* market wage contract at time t for an employee of ability ϕ_t as a contract such that $c^*(\phi_t, t) > 0$, that is, a contract that guarantees positive wages at all times prior to bankruptcy. The following proposition (with proof in the appendix) shows that if the market wage contract is feasible, it is optimal.

Proposition 1 *If the market wage contract is feasible at time* 0*, it is the optimal contract for an employee hired at time* 0*, that is, it is the unique solution to the program defined by Equations* (9)–(13).

Proposition 1 shows that, as long as the firm can meet its interest obligations without cutting the employee's wage, the optimal contract is similar to that in Harris and Holmström (1982): Wages never fall and they rise in response to positive shocks in employee ability. Employees therefore often become entrenched, i.e., they earn more than their competitive market wage.

The main difference between our results and those of Harris and Holmström (1982) occurs when the firm is in financial distress and the firm's revenues less the promised wage do not cover the interest owed:

$$\frac{Kr}{1-\tau} + \phi_t - \overline{c}_t \le Dr,$$

or equivalently when $\phi_t < \phi^*(\overline{c}_t)$, where

$$\phi^*(\overline{c}_t) \equiv \overline{c}_t - \left[\frac{K}{1-\tau} - D\right] r. \tag{16}$$

The firm pays zero dividends when it is in distress, and the employee takes a temporary pay cut (rather than forcing the firm into bankruptcy and taking a new job), receiving all cash left over after making the debt payments. That is, in financial distress,

$$\begin{aligned} c_t &= \frac{Kr}{1-\tau} + \phi_t - Dr, \\ &\leq \bar{c}_t. \end{aligned}$$

If the employee's productivity improves again such that $\phi_t \geq \phi^*(\bar{c}_t)$, then the firm resumes paying the promised wage $\bar{c}_t$.

If the employee gives up all his wages and the firm still cannot make interest payments, it is forced into bankruptcy. An earlier bankruptcy filing cannot make the employee better off because, by Lemma 1 in the Appendix, an employee can never make more money at any point in the future by accepting a new competitive wage contract at another firm. So the employee cannot be made worse off by delaying bankruptcy to the last possible moment, justifying our initial assumption on T.

Note that when the employee loses his job at time T, he cannot find another job at a positive wage because $0 = c_T \geq c^*(\phi_T, T)$. Hence, the employee chooses not to work and receives zero forever (effectively, the reservation wage in this model). The assumption that he cannot subsequently improve his ability level (e.g., through retraining, perhaps in another industry) is made primarily for modeling simplicity, though long-term unemployment following a bankruptcy is not uncommon.

3 Implementing the Optimal Contract

In this section, we make parametric assumptions about the evolution of the employee's ability, allowing us to determine the optimal contract and the value of the firm in closed form for a given debt level. Because we assume that capital and labor markets are competitive, all firms will pick the level of debt that maximizes the employee's utility, or else they will not be able to hire. Under the optimal wage contract, we derive an explicit expression for the employee's indirect utility as a function of the level of debt, and maximize this function to find the optimal debt level.

Our first additional assumption is that ability, ϕ_t, follows a random walk,

$$d\phi_t = \sigma \, dZ, \tag{17}$$

where Z is a Wiener process. Because the drift and volatility of ϕ_t are constant, neither the value of the firm nor the optimal contract now depends explicitly on t. The relevant history can be summarized via the running maximum of the ϕ_t process, and the optimal labor contract can be written in the more compact form:

$$c_t = \min\left\{\phi_t + r\left[\frac{K}{1-\tau} - D\right], c^*(\overline{\phi}_t)\right\}, \tag{18}$$

where

$$\overline{\phi}_t \equiv \max_{0\le s\le t} \phi_s,$$
$$c^*(\overline{\phi}_t) \equiv c^*(\overline{\phi}_t, \cdot).$$

Because the value of equity, V_t, does not depend on t, we will henceforth write $V(\phi_t, \overline{\phi}_t) \equiv V_t$.

To ensure that $c_0 > 0$, we assume that

$$\phi_0 > \frac{\sigma}{\sqrt{2r}} - \frac{Dr\tau}{1-\tau}. \tag{19}$$

The following proposition (with proof in the appendix) derives expressions for the value of the firm's equity and the employee's optimal wage contract for a given level of debt:

Proposition 2 *The value of the firm's equity at time t is*

$$V(\phi_t, \overline{\phi}_t) = \begin{cases} H(\overline{\phi}_t)e^{\sqrt{2r}\,\phi_t/\sigma} + M(\overline{\phi}_t)e^{-\sqrt{2r}\,\phi_t/\sigma} + \frac{(\phi_t - c^*(\overline{\phi}_t))(1-\tau)}{r} + K - D(1-\tau) & \text{if } \phi_t \ge \phi_t^* \\ Q(\overline{\phi}_t)e^{\sqrt{2r}\,\phi_t/\sigma} + G(\overline{\phi}_t)e^{-\sqrt{2r}\,\phi_t/\sigma} & \text{if } \phi_t < \phi_t^* \end{cases}$$

where $\phi_t^* \equiv \phi^*(c^*(\overline{\phi}_t))$, and the functions $H(\cdot), M(\cdot), Q(\cdot)$, and $G(\cdot)$ are given in the appendix. The competitive market wage, $c^*(\overline{\phi}_t)$, is uniquely defined via

$$c^*(\overline{\phi}_t) \equiv \left\{c \,\middle|\, \Delta(\overline{\phi}_t, D, c) = 0, \overline{\phi}_t + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}} \le c < \overline{\phi}_t + \frac{Dr\tau}{1-\tau}\right\},$$

where

$$\begin{aligned}\Delta(\overline{\phi}, D, c) \equiv\ & \left(2\sqrt{2}\left(\frac{D-K}{1-\tau}\right)r^{3/2} + \left(e^{-\frac{\sqrt{2r}\,c}{\sigma}} - e^{\frac{\sqrt{2r}\,c}{\sigma}}\right)\sigma\right)e^{\frac{\sqrt{2r}\left(\left(\frac{K}{1-\tau}-D\right)r+\overline{\phi}\right)}{\sigma}} - \sigma - \\ & \sqrt{2r}\left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau}\right) + e^{\frac{2\sqrt{2r}\left(\left(\frac{K}{1-\tau}-D\right)r+\overline{\phi}\right)}{\sigma}}\left(\sigma - \sqrt{2r}\left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau}\right)\right).\end{aligned}$$

The optimal level of debt is obtained by maximizing the employee's expected utility subject to the competitive wage contract derived in Proposition 2. For a given debt level, the employee's expected utility is given by

$$J(\phi,\overline{\phi}) \equiv E\left[\int_0^\infty e^{-rt}u(c_t)\,dt\,\middle|\,\phi_0=\phi\right],$$

where c_t follows the optimal wage policy derived in Proposition 2 until bankruptcy, and is equal to zero thereafter. The following proposition (with proof in the appendix) derives an explicit expression for J, under the additional assumption that the employee's preferences are given by

$$u(c) = -e^{-\gamma c}.$$

Proposition 3 *The employee's expected utility at time t is*

$$J(\phi_t,\overline{\phi}_t) = \begin{cases} A(\overline{\phi}_t)e^{\sqrt{2r}\,\phi_t/\sigma} + B(\overline{\phi}_t)e^{-\sqrt{2r}\,\phi_t/\sigma} - \frac{e^{-\gamma c^*(\overline{\phi})}}{r} & \text{if } \phi_t \geq \phi_t^* \\ C(\overline{\phi}_t)e^{\sqrt{2r}\,\phi_t/\sigma} + F(\overline{\phi}_t)e^{-\sqrt{2r}\,\phi_t/\sigma} - \frac{e^{-\gamma(\phi_t-\underline{\phi})}}{r-\frac{\gamma^2\sigma^2}{2}} & \text{if } \phi_t < \phi_t^* \end{cases}$$

where the functions $A(\cdot), B(\cdot), C(\cdot)$, and $F(\cdot)$ are given in the appendix.

Writing J as an explicit function of D, $J(\phi,\overline{\phi},D)$, the optimal level of debt now solves the first order condition

$$\frac{\partial}{\partial D}J(\phi_0,\phi_0,D) = 0. \tag{20}$$

Note that $\overline{\phi}_0 = \phi_0$ because when the employee is hired, or at any other time he is given a pay increase, the running maximum value of ϕ equals its current value. Given our explicit expression for J in Proposition 3, this equation is relatively straightforward to solve numerically, the only complication being that $c^*(\overline{\phi}_t)$ is only defined implicitly (in Proposition 2).

4 Quantitative Implications

The model is too simple to capture all the complexities of actual capital structure decisions, but we can use it to evaluate whether, for economically realistic parameters, human capital risk is of the same order of magnitude as the tax shield. In order to do so, we use the parameters listed in Table 1.

We assume a tax rate of 15% (lower than the U.S. corporate income tax rate) to compensate for the tax advantage of dividend income at the personal level.[12] Initially, the employee

[12]See Berk and DeMarzo (2007), p. 474, for a discussion of the effective tax advantage of debt at current tax rates.

is able to produce $\phi_0 = \overline{\phi}_0 = \$100,000$ annually, and the required amount of capital is $K = \$3$ million. With $r = 3\%$, the pre-tax (post-tax) annual revenue attributable to capital is $KR = \$106,000$ ($Kr = \$90,000$), so at these parameter values the revenue attributable to capital and labor are approximately the same.[13]

We do not actually observe employee ability, so the value of σ, its standard deviation, must be determined indirectly. Because ability follows a random walk, worker productivity does not increase on average (there is no on the job learning) making direct comparisons with actual wage distributions problematic. Even so, when we set $\sigma = 25\% \times \overline{\phi}_0$, we obtain a fairly realistic distribution of wages relative to the initial wage. After 10 years, 79% of workers earn a wage in excess of their starting wage, and very few workers are either unemployed (2.5%) or working below their contracted wage (6.6%).

Variable	Symbol	Value
Capital	K	\$3 million
Initial ϕ	$\overline{\phi}$	\$100,000
Interest Rate	r	3%
Tax Rate	τ	15%
Standard Deviation	σ	25,000
Risk Aversion	γ	3×10^{-6}

Table 1: **Parameter Values**

We use a coefficient of absolute risk aversion $\gamma = 3 \times 10^{-6}$. For consistency with experimental work, we need to convert this estimate into a measure of relative risk aversion, which requires calculating the employee's wealth. We derive an estimate of wealth as follows (the details can be found in the appendix). We first calculate $J(\phi_0, \phi_0)$, the employee's current level of utility assuming that she is newly employed (or has just gotten a pay increase) under the optimal wage contract with the optimal level of debt. We then find the riskless perpetuity that generates the same level of utility, and define wealth to be the present value of this perpetuity. Multiplying this estimate of wealth by the coefficient of absolute risk aversion then provides a measure of relative risk aversion, RRA:

$$RRA = -\frac{\log(-J(\phi_0, \phi_0)r)}{r}. \tag{21}$$

For the parameters in Table 1, and with a debt-equity ratio of .853 (which will turn out to

[13]At first glance, the roughly equal importance of labor and capital might seem at odds with the empirical estimate of labor's share of income of about 75%, (see, for example, Krueger (1999)), but that estimate is derived from the national income accounts and is unlikely to be representative of labor's share of revenue of a publicly traded corporation. A reason firms choose to go public is access to capital markets, so capital-intensive firms are much more likely to go public.

be optimal), the employee's wealth is \$3.5 million. Multiplying by the coefficient of absolute risk aversion gives a relative risk aversion coefficient of 10.43, the upper end of the range of plausible values reported in Mehra and Prescott (1985). There are good reasons to use an estimate at the upper end of this range. As we pointed out in the introduction, the evidence on happiness suggests that the uncertainty of job loss is one of the biggest risks economic agents face, more important than merely the loss in wealth.

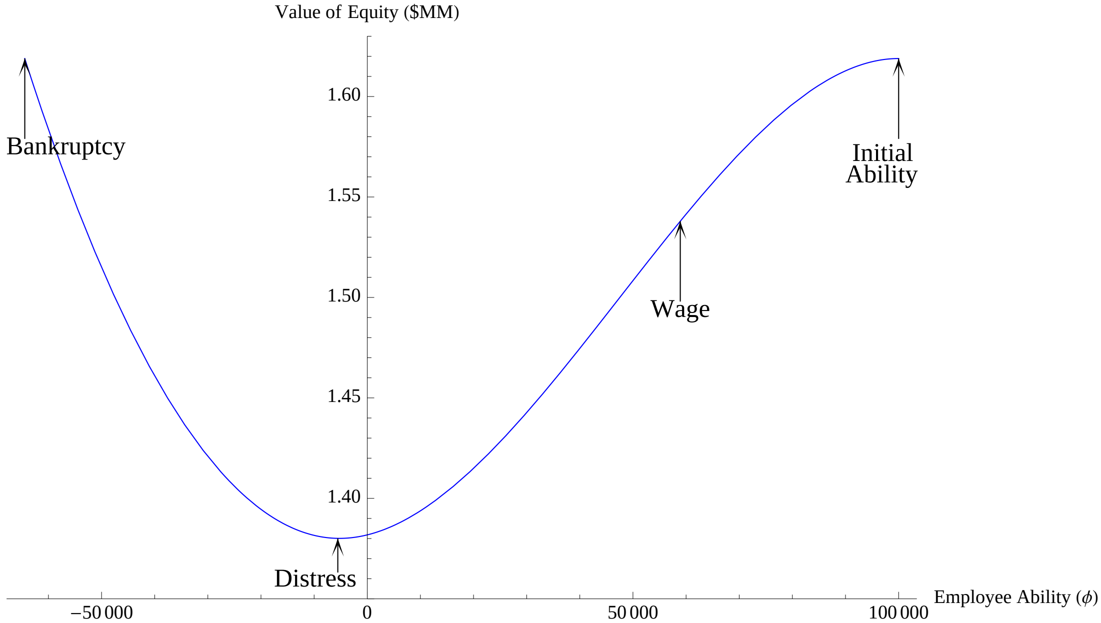
Figure 1 plots the value of equity under the optimal wage contract as a function of the employee's ability for the parameter values listed in Table 1 and a debt-to-equity ratio of 0.853. The value of equity equals the initial equity investment any time the employee earns his competitive market wage. Because we have no direct bankruptcy costs in this model, the value of equity also equals its initial value at the point of bankruptcy. That is, equity holders benefit from a bankruptcy filing because they can replace an unproductive employee with a productive one and thus restore firm value. The costs of bankruptcy accrue ex ante not ex post.

At all other points, the value of equity is below the amount of the initial equity investment. Initially, as ϕ decreases, so does the value of the firm's equity since the manager is adding less and less value to the firm. However, as ϕ drops still further, we get closer to the point at which the firm can fire the employee and replace him with someone more productive. For low enough values of ϕ, this second effect dominates, and the graph becomes downward sloping, as seen in the left hand segment of Figure 1.

Note that the value of the firm can never exceed the replacement value of its physical capital, that is, its Tobin's q ratio is always less than 1. This is the opposite of what Tobin's q theory predicts. There, the value of the firm is never lower than the replacement value of physical capital. Even so, equity holders always receive a fair market return because, when the employee is hired (or given a pay raise), it is at a wage below her ability: $\overline{c}_0 = \$58,907$ in this case, and her initial ability is $\overline{\phi}_0 = \$100,000$. This difference, plus the tax shield, generates a positive cash flow (dividend) to equity holders that compensates for the drop in the value of equity and guarantees equity holders the competitive market expected return.

Figure 2 shows the derived utility function, J, as a function of the debt-to-equity ratio. The debt-to-equity ratio that maximizes utility is marked with an arrow. The thick line plots the parameters in Table 1. The other lines use the parameter values from Table 1 with one parameter changed in each case — this changed parameter takes the value indicated on each curve. As the plot makes clear, the model is capable of generating large cross-sectional dispersion in the optimal debt-to-equity ratio. If the tax rate is raised to 20%, the optimal debt-equity ratio rises from 0.853 to 1.58. On the other hand, if either the volatility of the firm's cash flows or the risk aversion of the employee is increased, the optimal debt-equity

Figure 1: **Value of Equity:** The plot shows the value of equity as a function of employee ability (ϕ) between $\underline{\phi} = -\$64,000$ and $\overline{\phi} = \$100,000$. The parameter values are listed in Table 1, with a debt-to-equity ratio of 0.85 (which is optimal). The horizontal axis is in dollars and the vertical axis is in millions of dollars.

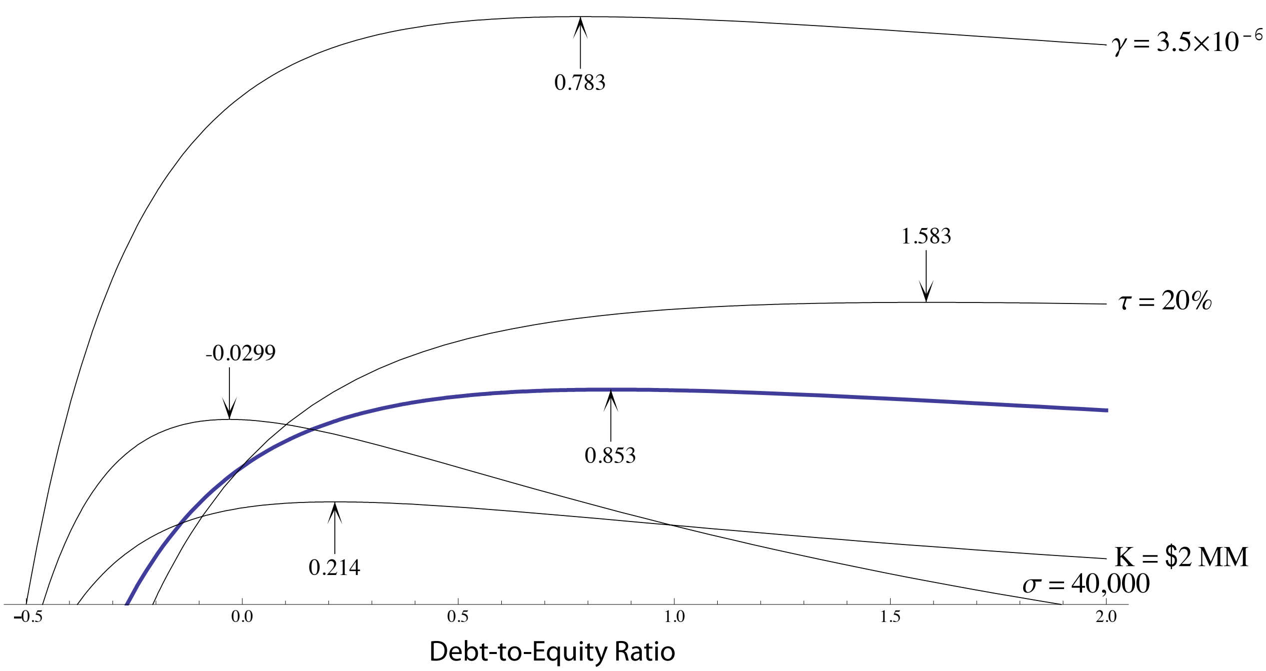


ratio drops. Indeed, the increase in the uncertainty is dramatic enough that the firm chooses to hold cash (optimal debt-equity ratio, -0.3, is negative) despite its tax disadvantages (the firm must pay tax on the interest earned, whereas investors do not because there are no personal income taxes in this model). Similarly, if the labor intensity of the firm is increased by reducing the amount of capital to \$2 million, the debt-equity ratio drops to 0.21.

Solving the first order condition, Equation (20), yields the optimal debt-to-equity ratio for any given set of parameters. Figure 3 plots the optimal debt-to-equity ratio as a function of the level of employee risk aversion, γ, for three different levels of σ, the volatility of employee productivity. It confirms what is intuitively clear in our model — leverage is related to employees' willingness to bear risk. Firms with more risk-averse employees optimally have lower levels of leverage, as do firms with more volatile labor productivity. When employees value human capital insurance more, either because they are more risk-averse or because their productivity is more volatile, firms optimally respond by reducing debt (and thus give up tax shields) to enhance risk sharing. These results suggest two empirical implications of our model: All else equal, firms with more idiosyncratic volatility should hold less debt, as should firms with more risk-averse employees. This relation between leverage and employee risk aversion is, to our knowledge, an implication unique to this model.

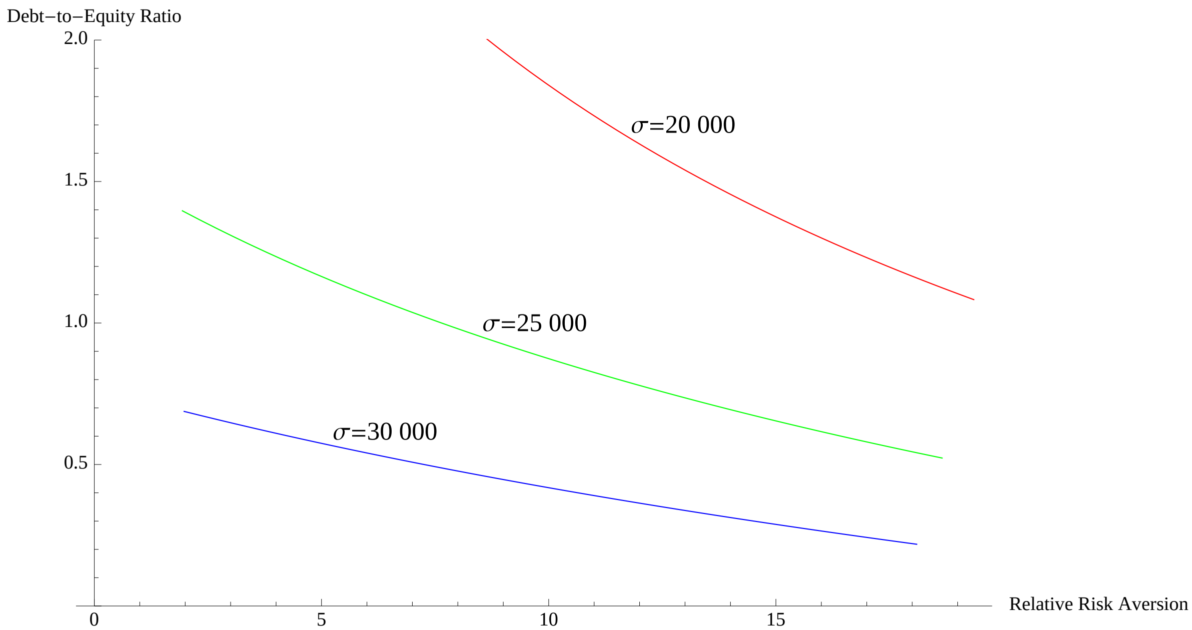
At first blush, risk aversion might appear to be an unlikely driver of cross-sectional

Figure 2: **Employee's Derived Utility:** The thick curve shows the employee's utility, J, as a function of the debt-to-equity ratio for the parameters in Table 1. The thinner curves show the employees utility with just the indicated parameter changed to the value indicated on the curve. The arrows mark the maximum value of each function, that is, the optimal debt-to-equity ratio.



variation in firm leverage. The corporations that comprise most studies have thousands of employees; if differences in risk aversion amongst employees are uncorrelated with each other, the average risk aversion of a typical employee in different firms will be about the same. However, an important implication of our model is that differences in risk aversion are unlikely to be uncorrelated within a firm. To understand why, first note from Figure 3 that the firm's optimal leverage is related to the risk aversion of its employees. This implies that it is not optimal for all (otherwise identical) firms to have the same leverage in an economy in which employees have different levels of risk aversion. Less risk-averse employees are better off working for firms with higher leverage, and more risk-averse employees are better off working for firms with lower leverage. Hence, because new hires will select firms based on their leverage (and offered wages), they will prefer to work for firms with employees that have similar levels of risk aversion. Firms therefore preferentially hire employees with similar preferences, and so cross-sectional differences in risk aversion, and thus leverage,

Figure 3: **Optimal Debt-to-Equity ratio as a Function of Employee Risk Aversion:** The plot shows the optimal debt-to-equity ratio as a function of the level of risk aversion, γ, converted to relative risk aversion using Equation (21). The three curves correspond to three different levels of volatility in labor productivity, σ. The values of the remaining parameters are listed in Table 1.



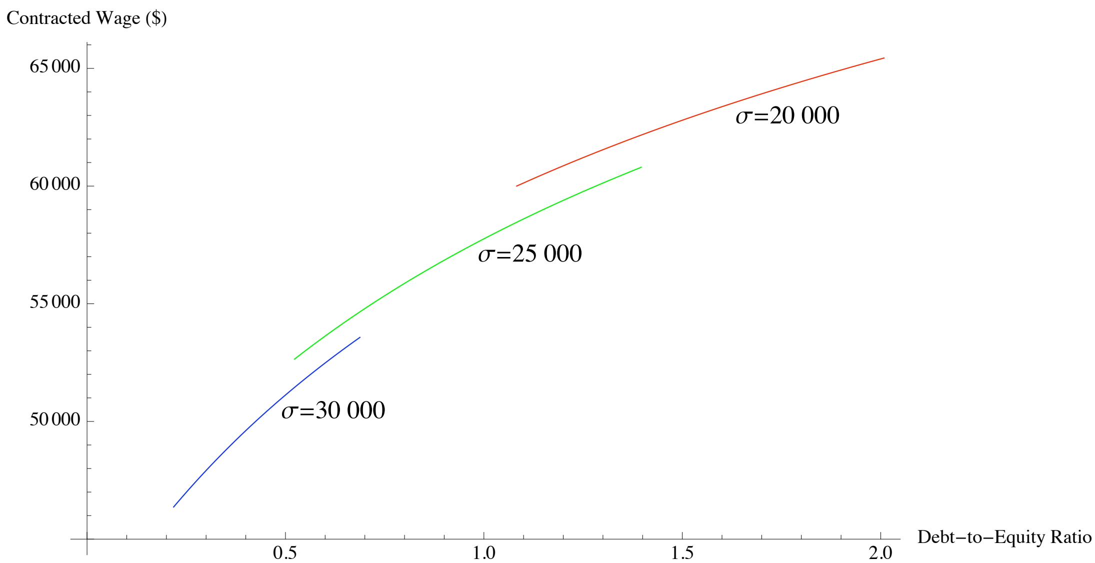
should persist.[14]

Figure 4 shows the cross-sectional distribution of initial contracted wages and debt levels for firms with different levels of employee risk aversion. Each line in the figure corresponds to a different level of volatility in labor productivity. Because employee risk aversion is difficult to observe, its role in capital structure is difficult to test directly. However, as Figure 4 demonstrates, the relation between wages and leverage can be used as an indirect test of the importance of employee risk aversion in explaining cross-sectional variation in firm capital structure. As is evident from the plot, higher leverage is associated with higher contracted wages, even after controlling for other sources of wage differentials such as cash flow volatility. Thus, wages should have explanatory power for firm leverage.[15]

[14]Graham et al. (2008) find evidence of cross sectional variation in employee risk aversion, and Bertrand and Schoar (2003) find evidence that characteristics specific to the CEO affects the firm's leverage. One might conjecture that this clientele explanation for persistent cross sectional variation in risk aversion is implausible because relatively few actual employees are aware of their employers' capital structures. But this objection misses an essential feature of actual labor markets. Although most employees are unaware of the amount of debt their employer has (except, perhaps, when their firm is in financial distress) most employees have a sense of their firm's "safety," that is, the probability that the firm will "survive." Employees expect higher wages when they choose to work for firms they deem less "safe."

[15]In testing this relation empirically, it is important to control for employee ability. Clearly, firms with

Figure 4: **Firms with Higher Leverage Pay Higher Wages:** The plot shows the cross-sectional distribution of initial contracted wages and debt levels for firms that vary in their employee risk aversion (as plotted in Figure 3). Each line corresponds to different levels of volatility in labor productivity.



In an empirical test motivated by our prediction, Chemmanur et al. (2008) find evidence of a relation between firm leverage and average firm wages as well as CEO compensation. Cross sectional variation in risk aversion has the potential to explain at least some of the large unexplained persistent cross-sectional variation in leverage within industries documented in Lemmon et al. (2008).

All else equal, firms with more risk-averse employees will provide more insurance and hence will choose to hold less debt, so their employees are more likely to become entrenched. Figure 5 quantifies this effect for firms that vary in employee risk aversion and volatility of labor productivity as plotted in Figure 3. The average level of entrenchment after 10 years is calculated by simulating wages. For each sample path for which the employee is still employed by the firm, the difference between the actual wage earned and the employee's competitive wage after 10 years is calculated. The plot reports the average over 100,000 paths, conditional on not being fired, for each level of risk aversion and volatility. Note that the absolute level of entrenchment is large. Firms with low debt-equity ratios have employees

higher ability employees will pay higher wages, suggesting the inclusion of controls for firm industry. Even for firms with employees of similar current ability, ϕ, it is necessary to control for the history of ϕ because this also affects current wages and may vary across firms. Cross-sectional empirical studies could control for this using instruments such as realized returns (in excess of expected returns) or accounting profitability measures.

whose average wages exceed their competitive wage by about $40,000. Even at high debt-equity ratios, the average level of entrenchment is still significant. What this implies is that the cost to employees of a bankruptcy filing should be large, consistent with the anecdotal evidence reported in the popular press.

Figure 5: **Firms with Higher Leverage Have Lower Average Entrenchment:** The plot shows the cross-sectional distribution of average entrenchment after 10 years of employment and leverage levels for firms that vary in their employee risk aversion (as plotted in Figure 3). Average entrenchment is defined to be the average difference (over 100,000 sample paths), conditional on ten years of employment, between the employee's actual annual wage and his competitive wage. Each line corresponds to different levels of volatility in labor productivity.

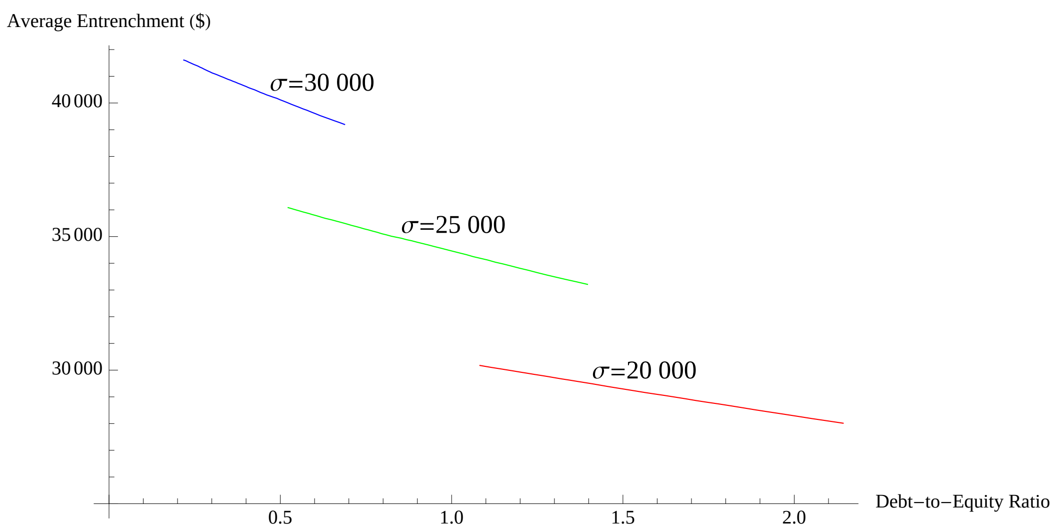
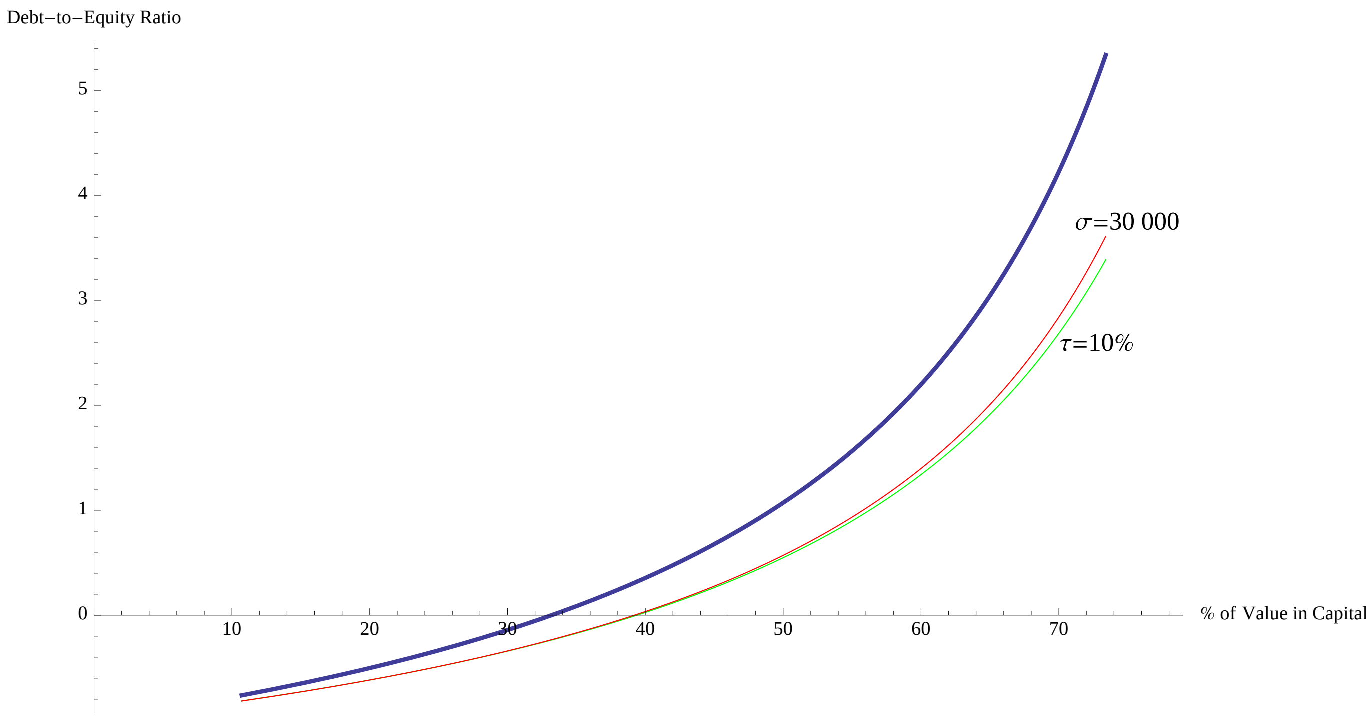


Figure 6 plots the optimal debt-to-equity ratio as a function of the fraction of revenues attributable to capital. Keeping $\phi_0 = \$100,000$, the amount of capital, K, is varied from $400,000 to $13 million, corresponding to a variation in the fraction of revenue attributable to capital from about 10% to 80%. From the figure, labor-intensive firms have lower levels of debt and very labor-intensive firms may even have negative debt-equity ratios — they choose to hold cash. Rajan and Zingales (1995) find that the ratio of fixed assets to book value of assets is significantly positively related to leverage in almost every country they study. Because the ratio of fixed assets to book value is likely to be higher for capital-intensive firms, their result is consistent with the predictions of our model. Further, as the figure makes clear, at low tax rates or high levels of productivity volatility, even firms that are not labor-intensive may hold negative debt (that is, significant levels of cash), despite its tax disadvantages. Finally, because capital-intensive firms tend to be large (especially if

Figure 6: **Firm Size and Debt Levels:** The plot shows the optimal debt-to-equity ratio as a function of the amount of capital K, expressed as a percentage of revenue attributable to capital (K is varied from \$400,000 to \$13 million). The thick curve uses the values of the parameters listed in Table 1. The two thinner curves plot the optimal debt-to-equity ratio with the indicated parameter set equal to the value indicated on the curve and the remaining parameters set equal to the values listed in Table 1.



accounting numbers are used as a measure of firm size), this finding also implies that larger firms should have higher leverage, consistent with the empirical evidence.[16]

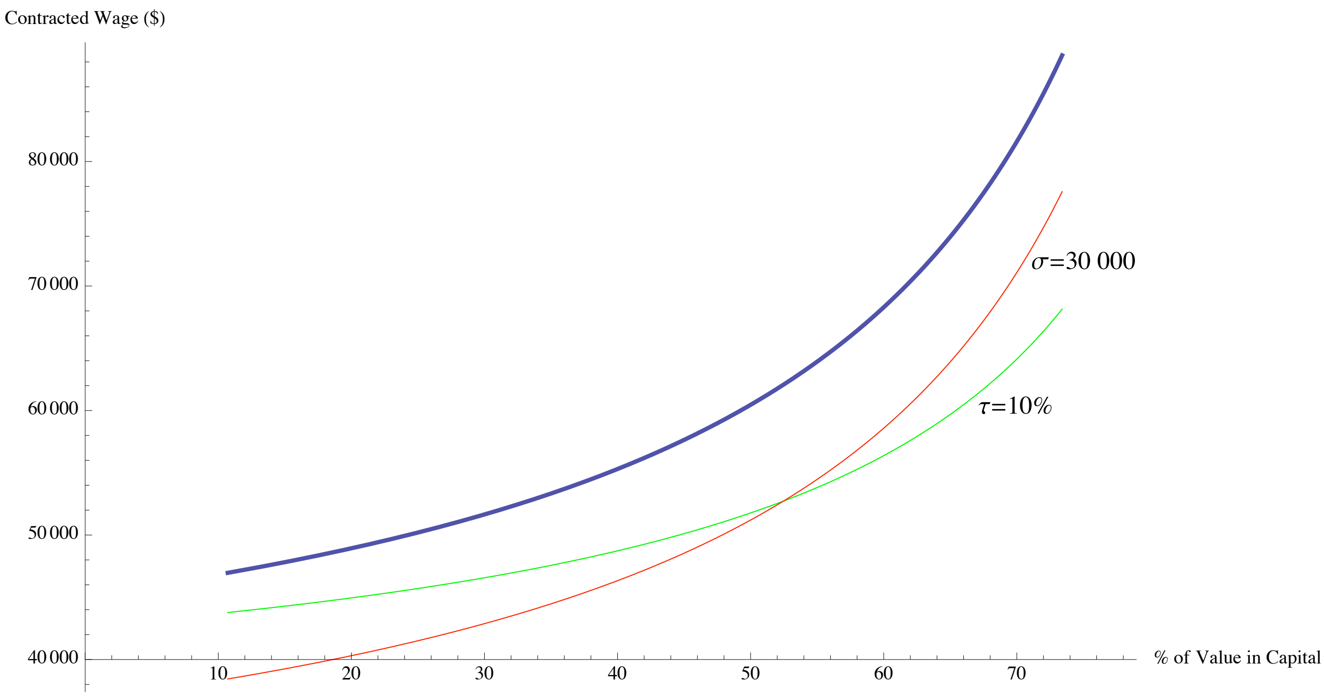
An interesting question is what the cross-sectional variation in the capital versus labor intensity of firms implies about wages. For a given level of debt, labor-intensive industries have a higher probability of bankruptcy, so one would expect higher initial contracted wages in these industries. However, these firms endogenously respond by issuing less debt (or even holding cash), thus decreasing the probability of bankruptcy. Figure 7 shows that this endogenous response is enough to reverse the initial effect: Holding the initial productivity of labor fixed, capital-intensive firms, and hence larger firms, pay *higher* initial wages.[17] This relation between firm size and wages is a robust characteristic of the data and is regarded

[16] See, for example, Rajan and Zingales (1995). Another possible explanation for the relation between firm size and leverage is that using capital as collateral may reduce dead-weight bankruptcy costs.

[17] As with the relation between leverage and wages (see footnote 15), in testing this empirically, it is important to account for ability.

as a puzzle by labor economists (see Brown and Medoff (1989)).

Figure 7: **Capital-Intensive Firms Pay Higher Wages:** The plot shows the cross-sectional distribution of initial contracted wages (at optimal debt levels) for different levels of capital (K is varied from \$400,000 to \$13 million). The thick curve uses the values of the parameters listed in Table 1. The two thinner curves plot wages for the indicated parameter set equal to the value indicated on the curve and the remaining parameters set equal to the values listed in Table 1.



It is important to emphasize that the relation between leverage and capital intensity depends on our assumption that labor is riskier than capital. If we had instead assumed that capital was risky and labor riskless, this relation would be reversed. However, there are good reasons to suppose that, in general, labor is indeed riskier than capital. Note that the benefits of risk sharing between the corporation and the employee are related only to *idiosyncratic* risk — there is no obvious reason to share systematic risk. Key employees, such as the CEO, can make idiosyncratic decisions that have large consequences for the firm. It is hard to envision an analogous role for capital. Empirically, Bazdrech, Belo, and Lin (2008) find that labor-intensive firms have higher returns, consistent with their having higher risk, and Palacios (2008) finds that more labor-intensive firms have higher betas. Winn (1977), Daskin (1983), and Jacquemin and Saez (1986) all find a strong negative relation between firm size and the intertemporal variability of profits, and firm size is known to be positively correlated with capital intensity (see, for example, Caves and Pugel (1980) and Kumar, Rajan, and Zingales (1999)). Similarly, Lev (1983) finds a strong negative relation between firm size and the residual variance of sales and accounting profits in regressions involving lagged profitability (the residual variance is a better measure of the extent to which profits are unpredictable).

5 Discussion

An implication of this paper is that employees should care about the firm's likelihood of bankruptcy. However, in many cases, employees may not be able to calculate the precise relation between leverage and bankruptcy, so other more readily interpretable variables are likely to play a role in capital structure decisions. One such variable is the firm's credit rating. Although most employees are unlikely to be able to relate leverage levels to bankruptcy probabilities, rating agencies perform this mapping for them and publish their results. This risk-sharing view of capital structure is also in accordance with survey results reported by Graham and Harvey (2001). They find that the most important determinant of capital structure choice is financial flexibility and maintaining a good credit rating. By contrast, they find little evidence for asset substitution or asymmetric information as important factors for capital structure choice. While there are many advantages of financial flexibility and a good credit rating, one of them is the ability to share human capital risk more effectively with employees. This might be part of the reason why managers focus on these particular factors.

Our model predicts an inverse relation between leverage and entrenchment. Berger, Ofek, and Yermack (1997) and Kayhan (2003) both find that firms with employees who appear more entrenched have low leverage. Bebchuk and Cohen (2005) investigate the effect of managerial entrenchment on market valuation. Consistent with the predictions of our model, they find that firms with managers that are more likely to be entrenched display lower Tobin's q ratios. They leave as a puzzle why shareholders would voluntarily engage in what they identify as suboptimal behavior. A contribution of our model is the insight that is is not necessarily suboptimal to let employees become entrenched, even if, ex post, this entrenchment leads to lower values of Tobin's q.

There is also empirical evidence consistent with our assumption that bankruptcy can benefit the investors in a firm because existing employees are fired, or their wages are reset to competitive levels. On a macroeconomic scale, Cochrane (1991) finds evidence that employees experience significant costs associated with involuntary job loss. At the firm level, Gilson (1989, 1990), Jacobson, LaLonde, and Sullivan (1993) and Gilson and Vetsuypens (1993) all find evidence that employees are replaced, experiencing large personal costs, when firms enter financial distress or bankruptcy. Gilson (1989) finds that 52% of sampled firms experience turnover in senior management during distress or bankruptcy, and that, following these separations, these executives have difficulty finding comparable employment. Two years following a bankruptcy filling or reorganization, Gilson (1990) finds only 43% of CEOs remain in their jobs. Gilson and Vetsuypens (1993) find that at the time of bankruptcy almost 1/3 of all CEOs are replaced, and those who keep their job experience large cuts in compensation (35% or so). Further, when new outside managers are hired, they are paid 36% more than the fired managers, consistent with our prediction that employees take pay cuts when the firm is in distress. Jacobson et al. (1993) find that high tenure workers (those that under our assumptions are most likely to be entrenched) suffer long-term losses averaging 25% per year when they leave distressed firms. More recently, Eckbo and Thorburn (2003) find, for a Swedish sample, that the median income change for CEOs resulting from a bankruptcy is −47%. Finally, Kalay, Singhal, and Tashjian (2007) find that firms experience significant improvements in operating performance during Chapter 11 bankruptcy, suggesting that, by firing old employees and hiring new ones at their market wage, value is created.[18]

A key insight that emerges from our analysis is the role of bankruptcy in limiting the potential to write explicit or implicit contracts with employees. Although bankruptcy is probably the most important mechanism that allows firms to abrogate existing contracts, other mechanisms, such as takeovers, also exist. When a firm is merged into another company, it becomes easier to fully or partially abrogate implicit (and possibly also explicit) contracts. Consistent with this view, Pontiff, Shleifer, and Weisbach (1990) find that hostile takeovers are followed by an abnormally high incidence of pension asset reversions, which account for approximately 11% of takeover gains.[19] That hostile takeovers may create value gains ex post is widely recognized. What this paper adds is that they also limit the risk sharing possibilities ex ante, which might explain why the majority of firms have adopted anti-takeover provisions.

6 Conclusion

It is widely accepted that capital structure choice is a tradeoff between the costs and benefits of debt. However, although there is broad agreement among academics and practitioners on the benefits of debt, identifying its costs has presented more of a puzzle. Most existing papers

[18]Other possible explanations for the improvement in operating performance have been suggested, such as preferential tax treatment during bankruptcy. However, the main efficiency measure used by Kalay et al. (2007) is EBITDA, a pretax measure, suggesting that the effects they are documenting are not tax-related.

[19]A pension asset reversion allows a firm to recoup the over-funded portion of its pension plan.

on capital structure require firms (or their investors) to bear sizable bankruptcy costs, but the empirical evidence does not support this. In contrast, there is evidence that bankruptcy costs borne by employees of the firm are significant, yet these have not received much attention in the finance literature. Our analysis demonstrates that, at reasonable parameter values, the bankruptcy costs borne by employees can, in fact, provide a first-order counterbalance to the tax benefits of debt.

Analyzing the human cost of bankruptcy generates a rich set of empirical predictions. First, under realistic tax rates, the model can produce moderate leverage ratios, implying an apparent "underutilization" of debt tax shields if these costs are ignored. Second, the model predicts variation in the average risk aversion of employees across firms, and that this variation should result in persistent variation in leverage ratios. Third, highly levered firms should pay higher wages to newly hired employees. Fourth, controlling for firms' historical profitability, capital-intensive firms in our model have higher optimal leverage ratios and pay higher wages. Finally, riskier firms choose lower leverage ratios.[20]

An important simplifying assumption in our model is that we do not allow firms to make severance payments to fired employees prior to bankruptcy. Relaxing this assumption would complicate the analysis appreciably, but would not qualitatively change the results. The firm would be better off firing an unproductive employee prior to bankruptcy, and continuing to pay his contracted wage. A new replacement employee would be hired at a competitive wage, and the firm would now pay wages to current and all past employees. At the point of bankruptcy the firm stops making all wage payments (to both past and newly fired employees), so employees still continue to trade off the benefits of insurance against the benefits of the tax shield. Moreover, such severance payments are Pareto improving only if moral hazard concerns are ignored. In reality, the moral hazard benefits employees derive from being fired (they continue to earn an above market wage from their old employer and they can then supplement this income with a new job at the market wage) most likely explains why such contracts are uncommon.

Key to our results is the assumption that employment contracts do not survive bankruptcy. Given the costs imposed by the bankruptcy process on the employees of the firm, it is perhaps surprising that in reality firms do not write employment contracts that survive the bankruptcy process. For example, one solution that is in principle available would be for firms to issue zero coupon senior perpetual debt to its employees. The only effect this debt

[20] This prediction also comes out of several other theoretical models, including Fischer, Heinkel, and Zechner (1989), Leland (1994), and Strebulaev (2007). However, other models, such as Maksimovic and Zechner (1991) predict a positive relationship, and the empirical evidence is mixed: Kim and Sorensen (1986) find a positive relationship, Bradley, Jarrell, and Kim (1984) find a negative relationship, and Titman and Wessels (1988) find an insignificant relationship.

would have would be in bankruptcy, when it ensures that the employees gain control of the firm because they hold the most senior claims. The most likely reason we do not see such contracts is the associated moral hazard — in this case employees would have an incentive to drive the firm into bankruptcy. Indeed, as DeMarzo and Fishman (2007) show, this kind of moral hazard can, by itself, be a determinant of firms' capital structures.

Relaxing some of our other simplifying assumptions would lead to interesting extensions of the model. Both dividend policy and dynamic capital structure decisions are exogenous — the firm pays out all excess cash as dividends and never changes the level of debt. We make these assumptions for tractability; if managers could change debt levels over time, they could substantially reduce the costs of bankruptcy and financial distress. This issue is not just relevant to our model. As noted by Haugen and Senbet (1978), if bankruptcy costs can be avoided (either by renegotiation or dynamic capital structure/dividend policy), then *every* model that uses bankruptcy costs to limit leverage will have problems; firms should just set leverage to shield all cash.

More generally, we believe that recognizing the interaction between labor and capital markets opens a new and exciting path for future research in corporate finance. Analyzing the resulting implications could significantly improve our understanding of corporate behavior.

Appendix

A Lemmas

Lemma 1 *The market wage contract initiated at time ν cannot pay a lower wage than the market wage contract initiated at any later time: $c^*_{\nu,s} \geq c^*_{\hat{\nu},s}$ for all $s \geq \hat{\nu} \geq \nu$.*

Proof: From the definition of the market wage contract we have:

$$c^*_{t,s} = \min\left\{\phi_s + r\left[\frac{K}{1-\tau} - D\right], \max_{t\leq\nu\leq s}\{c^*(\phi_\nu,\nu)\}\right\},$$

from which the result follows immediately because for any $\hat{\nu} \geq \nu$,

$$\min\left\{\phi_t + r\left[\frac{K}{1-\tau} - D\right], \max_{\nu\leq s\leq t}\{c^*(\phi_s,s)\}\right\} \geq \min\left\{\phi_t + r\left[\frac{K}{1-\tau} - D\right], \max_{\hat{\nu}\leq s\leq t}\{c^*(\phi_s,s)\}\right\}.$$

∎

Lemma 2 *At initiation, the market wage contract pays the promised wage, that is, $c^*_{t,t} = c^*(\phi_t, t)$.*

Proof: Assume not, that is, assume that the initial wage is the financial distress wage, and let ν be the first time

$$c^*_{t,\nu} = \max_{t\leq s\leq\nu}\{c^*(\phi_s,s)\}.$$

If this condition is not met before time T, then define $\nu = T$. By Lemma 1, iterated expectations, and the definition of the market wage contract,

$$\begin{aligned}
0 &= E_t\left[\int_t^T \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] \\
&= E_t\left[\int_t^\nu \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] + E_t\left[\int_\nu^T \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] \\
&\leq E_t\left[\int_t^\nu \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] + E_t\left[\int_\nu^T \beta^{s-t}((\phi_s - c^*_{\nu,s})(1-\tau) + Dr\tau)\,ds\right] \\
&= E_t\left[\int_t^\nu \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] + E_tE_\nu\left[\int_\nu^T \beta^{s-t}((\phi_s - c^*_{\nu,s})(1-\tau) + Dr\tau)\,ds\right] \\
&= E_t\left[\int_t^\nu \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\,ds\right] \\
&= E_t\left[\int_t^\nu \beta^{s-t}(-r(K-D))\,ds\right] < 0,
\end{aligned}$$

the last line following by replacing $c^*_{t,s}$ with the financial distress wage. ∎

B Proof of Proposition 1

We wish to prove that the optimal compensation policy is to set

$$c_t = \min\left\{\phi_t + r\left[\frac{K}{1-\tau} - D\right], \max_{0\le s\le t}\{c^*(\phi_s, s)\}\right\}, \tag{22}$$

the market wage contract at time 0. The proof of this proposition closely follows that of Proposition 1 in Harris and Holmström (1982). We first show the policy in (22) is feasible.

Equations (12) and (13) are automatically satisfied by our definition of c_t in Equation (22) and feasibility. Equation (10) is satisfied by the definition of the market wage contract at time 0 and Lemma 2. In addition, by Lemma 1,

$$\begin{aligned} E_t\left[\int_t^T \beta^{s-t}((\phi_s - c^*_{0,s})(1-\tau) + Dr\tau)\, ds\right] &\le E_t\left[\int_t^T \beta^{s-t}((\phi_s - c^*_{t,s})(1-\tau) + Dr\tau)\, ds\right] \\ &= 0, \end{aligned}$$

the last line following from the definition of the market wage contract initiated at date t. Thus the market wage contract at time 0 satisfies Equation (11), and is hence feasible.

Next, we define specific Lagrange multipliers, and show that this compensation policy, together with those Lagrange multipliers, maximizes the Lagrangian and satisfies the complementary slackness conditions for the program (9)–(12). (Because the contract is feasible (13) is always strictly satisfied.) The Lagrangian can be written (after first multiplying the constraints (11) and (12) by the unconditional density of $\phi^t \equiv \{\phi_s : 0 \le s \le t\}$, multiplying (12) by powers of β, and then collecting terms) as follows:

$$E_0 \int_0^T \beta^t\left[u(c_t) + \lambda^t((\phi_t - c_t)(1-\tau) + Dr\tau) + \mu_t((c_t - \phi_t)(1-\tau) - r\left[K - D(1-\tau)\right])\right] dt, \tag{23}$$

where

$$\lambda^t \equiv \int_{s=0}^t d\lambda_s(\phi^s), \tag{24}$$

$\mu_t \le 0$ is the Lagrange multiplier corresponding to Equation (12), and $d\lambda_s(\phi^s) \le 0$ is the Lagrange multiplier corresponding to Equation (11). The first order conditions take the form

$$\frac{u'(c_t)}{1-\tau} = \lambda^t - \mu_t. \tag{25}$$

Assume that the Lagrange multipliers are given by

$$\lambda^t = \frac{u'\left(\max_{0\le s\le t}\left\{c^*(\phi_s,s)\right\}\right)}{1-\tau}, \tag{26}$$

$$\mu_t = \frac{u'\left(\max_{0\le s\le t}\left\{c^*(\phi_s,s)\right\}\right) - u'\left(\min\left\{\phi_t + r\left[\frac{K}{1-\tau} - D\right], \max_{0\le s\le t}\left[c^*(\phi_s,s)\right]\right\}\right)}{1-\tau}. \tag{27}$$

When c_t is given by (22) the first order conditions given by Equation (25) with these Lagrange multipliers are satisfied. Because the maximum inside the bracket in Equation (26) is always increasing, we have immediately that

$$d\lambda_t \begin{cases} \le 0 & \text{when } c^*(\phi_t,t) = \max_{0\le s\le t}\left\{c^*(\phi_s,s)\right\}, \\ = 0 & \text{otherwise.} \end{cases} \tag{28}$$

In words, $d\lambda_t$ is only non-negative when the employee earns his competitive market wage (because, by Lemma 2 the firm can never be in distress when the employee earns his competitive wage) or equivalently when (11) binds. Thus, $d\lambda_t = 0$ whenever (11) does not bind. Equation (27) immediately tells us that

$$\mu_t \begin{cases} = 0 & \text{when } c_t = \max_{0\le s\le t}\left\{c^*(\phi_s,s)\right\}, \\ \le 0 & \text{otherwise,} \end{cases} \tag{29}$$

so $\mu_t = 0$ whenever (12) does not bind. Hence, we have complementary slackness and a solution to the problem. Finally, note that because $u(\cdot)$ is concave and the constraints form a convex set, the problem has a unique solution. The contract defined by Equation (14) is thus the unique solution to the original program, Equations (9)–(12).

C Proof of Proposition 2

By Ito's Lemma, when $\phi_t < \overline{\phi}_t$,

$$dV = V_\phi\, d\phi + \frac{1}{2} V_{\phi\phi}\sigma^2\, dt. \tag{30}$$

In equilibrium, shareholders must earn a fair rate of return on their investment, implying that

$$E(dV) = (rV - \delta_t)\, dt,$$

where δ_t is the dividend payment, Combining these, we obtain a p.d.e. for $V(\phi, \overline{\phi})$:

$$\frac{1}{2}\sigma^2 V_{\phi\phi} - rV + \delta_t = 0. \tag{31}$$

From Equation (1), the dividend is given by

$$\delta_t = \begin{cases} Kr - Dr(1-\tau) + (\phi_t - c^*(\overline{\phi}))(1-\tau) & \text{if } \phi \geq \phi^*(\overline{\phi}), \\ 0 & \text{otherwise.} \end{cases} \tag{32}$$

Equation (31) thus takes two different forms, depending on whether or not the firm is currently in financial distress:

$$\frac{1}{2}\sigma^2 V_{\phi\phi} - rV + Kr - Dr(1-\tau) + (\phi - c^*(\overline{\phi}))(1-\tau) = 0 \qquad \text{if } \phi \geq \phi^*(\overline{\phi}), \tag{33}$$

$$\frac{1}{2}\sigma^2 V^f_{\phi\phi} - rV^f = 0 \qquad \text{otherwise.} \tag{34}$$

The notation V^f here is used to indicate the equity value when the firm is in financial distress. The general solutions to equations (33) and (34) are

$$V(\phi, \overline{\phi}) = H(\overline{\phi})e^{\sqrt{2r}\,\phi/\sigma} + M(\overline{\phi})e^{-\sqrt{2r}\,\phi/\sigma} + \frac{(\phi - c^*(\overline{\phi}))(1-\tau)}{r} + K - D(1-\tau), \tag{35}$$

$$V^f(\phi, \overline{\phi}) = Q(\overline{\phi})e^{\sqrt{2r}\,\phi/\sigma} + G(\overline{\phi})e^{-\sqrt{2r}\,\phi/\sigma}. \tag{36}$$

To pin down the four unknown functions H, M, Q and G, we need four boundary conditions. The first, applying at the upper boundary $\phi = \overline{\phi}$, is[21]

$$\left.\frac{\partial}{\partial\overline{\phi}}\right|_{\phi=\overline{\phi}} V(\phi, \overline{\phi}) = 0. \tag{37}$$

At the point the firm enters financial distress, $\phi^*(\overline{\phi})$, the values and derivatives must be matched, providing two additional boundary conditions,

$$V(\phi^*(\overline{\phi}), \overline{\phi}) = V^f(\phi^*(\overline{\phi}), \overline{\phi}), \tag{38}$$

$$V_\phi(\phi^*(\overline{\phi}), \overline{\phi}) = V^f_\phi(\phi^*(\overline{\phi}), \overline{\phi}). \tag{39}$$

Finally, at the point of bankruptcy (when the firm cannot meet its interest obligations even if the employee gives up all his wages), $\underline{\phi}$, the firm fires the employee and replaces him with

[21] See Goldman, Sosin, and Gatto (1979).

an employee who puts the capital to full productive use, so

$$V^f(\underline{\phi}, \overline{\phi}) = K - D. \tag{40}$$

These four boundary conditions are sufficient to pin down H, M, Q and G for any given specification of the wage function. However, we also want to determine the optimal wage function, $c^*(\overline{\phi})$. This requires an additional condition, which is that the value of equity at the moment the manager is hired must be equal to $K - D$, i.e.,

$$V(\overline{\phi}, \overline{\phi}) = K - D. \tag{41}$$

As written, the five equations (37)–(41), are enough in principle to determine H, M, Q, G and c^*, but applying them directly results in o.d.e.s for each function, due to the presence of the $\overline{\phi}$ derivative in Equation (37). To eliminate this derivative, we replace Equation (37) with another (equivalent) condition. To do this, note that because Equation (41) holds for all $\overline{\phi}$, we can differentiate it with respect to $\overline{\phi}$, obtaining

$$\begin{aligned} \frac{dV(\overline{\phi}, \overline{\phi})}{d\overline{\phi}} &= \left.\frac{\partial V(\phi, \overline{\phi})}{\partial \phi}\right|_{\phi=\overline{\phi}} + \left.\frac{\partial V(\phi, \overline{\phi})}{\partial \overline{\phi}}\right|_{\phi=\overline{\phi}}, \\ &= 0. \end{aligned}$$

Combining this with Equation (37) we obtain

$$\left.\frac{\partial}{\partial \phi}\right|_{\phi=\overline{\phi}} V(\phi, \overline{\phi}) = 0. \tag{42}$$

Using (41), (42), (38), (39) and (40) to solve for the coefficients and the optimal wage gives:

$$
\begin{aligned}
H(\overline{\phi}) &= \frac{\left(4\left(\frac{D-K}{1-\tau}\right) r^{3/2}+\sqrt{2}e^{-\frac{\sqrt{2r}c}{\sigma}}\sigma-\sqrt{2}e^{\frac{\sqrt{2r}c}{\sigma}}\sigma\right)e^{\frac{\sqrt{2r}\underline{\phi}}{\sigma}}+4\sqrt{r}(c-\frac{D\tau r}{1-\tau}-\overline{\phi})e^{\frac{\sqrt{2r}\,\overline{\phi}}{\sigma}}}{\frac{4r^{3/2}}{1-\tau}\left(e^{\frac{2\sqrt{2r}\,\overline{\phi}}{\sigma}}-e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}}\right)}, \\
M(\overline{\phi}) &= \frac{\left(4\left(\frac{K-D}{1-\tau}\right) r^{3/2}-\sqrt{2}e^{-\frac{\sqrt{2r}c}{\sigma}}\sigma+\sqrt{2}e^{\frac{\sqrt{2r}c}{\sigma}}\sigma\right)e^{\frac{\sqrt{2r}(2\overline{\phi}+\underline{\phi})}{\sigma}}-4\sqrt{r}(c-\frac{D\tau r}{1-\tau}-\overline{\phi})e^{\frac{\sqrt{2r}(\overline{\phi}+2\underline{\phi})}{\sigma}}}{\frac{4r^{3/2}}{1-\tau}\left(e^{\frac{2\sqrt{2r}\,\overline{\phi}}{\sigma}}-e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}}\right)}, \\
Q(\overline{\phi}) &= \frac{4\left(\frac{D-K}{1-\tau}\right) r^{3/2}e^{\frac{\sqrt{2r}\underline{\phi}}{\sigma}}+\sqrt{2}\sigma\left(e^{-\frac{\sqrt{2r}(c+\underline{\phi}-2\overline{\phi})}{\sigma}}-e^{\frac{\sqrt{2r}(c+\underline{\phi})}{\sigma}}\right)+4\sqrt{r}(c-\overline{\phi}-\frac{D\tau r}{1-\tau})e^{\frac{\sqrt{2r}\,\overline{\phi}}{\sigma}}}{\frac{4r^{3/2}}{1-\tau}\left(e^{\frac{2\sqrt{2r}\,\overline{\phi}}{\sigma}}-e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}}\right)}, \\
G(\overline{\phi}) &= \frac{\left(4\left(\frac{K-D}{1-\tau}\right) r^{3/2}-\sqrt{2}e^{-\frac{\sqrt{2r}c}{\sigma}}\sigma\right)e^{\frac{\sqrt{2r}(2\overline{\phi}+\underline{\phi})}{\sigma}}-4\sqrt{r}(c-\frac{D\tau r}{1-\tau}-\overline{\phi})e^{\frac{\sqrt{2r}(\overline{\phi}+2\underline{\phi})}{\sigma}}+\sqrt{2}e^{\frac{\sqrt{2r}(c+3\underline{\phi})}{\sigma}}\sigma}{\frac{4r^{3/2}}{1-\tau}\left(e^{\frac{2\sqrt{2r}\,\overline{\phi}}{\sigma}}-e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}}\right)},
\end{aligned}
$$

and the wage is

$$c = c^*(\overline{\phi}),$$

where

$$c^*(\overline{\phi}) \equiv \left\{ c \,\middle|\, \Delta(\overline{\phi}, D, c) = 0, \overline{\phi} + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}} \leq c < \overline{\phi} + \frac{Dr\tau}{1-\tau} \right\}$$

and

$$
\begin{aligned}
\Delta(\overline{\phi}, D, c) \;\equiv\; & \left(2\sqrt{2}\left(\frac{D-K}{1-\tau}\right) r^{3/2} + \left(e^{-\frac{\sqrt{2r}\,c}{\sigma}} - e^{\frac{\sqrt{2r}\,c}{\sigma}}\right)\sigma\right) e^{\frac{\sqrt{2r}\left(\left(\frac{K}{1-\tau}-D\right)r+\overline{\phi}\right)}{\sigma}} - \sigma - \qquad (43) \\
& \sqrt{2r}\left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau}\right) + e^{\frac{2\sqrt{2r}\left(\left(\frac{K}{1-\tau}-D\right)r+\overline{\phi}\right)}{\sigma}}\left(\sigma - \sqrt{2r}\left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau}\right)\right).
\end{aligned}
$$

Appendix F proves that $\Delta(\overline{\phi}, D, c)$ always has a unique root between $\overline{\phi} + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}}$ and $\overline{\phi} + \frac{Dr\tau}{1-\tau}$.

D Proof of Proposition 3

For any $\phi \leq \overline{\phi}$, the Bellman equation for the manager's value function, J, takes the form

$$\frac{1}{2}\sigma^2 J_{\phi\phi} - rJ + u(c) = 0. \qquad (44)$$

The manager's pay, c, is given by

$$c = \begin{cases} c^*(\overline{\phi}) & \text{if } \phi \geq \phi^*(\overline{\phi}), \\ \phi + r\left(\frac{K}{1-\tau} - D\right) = \phi - \underline{\phi} & \text{otherwise.} \end{cases} \tag{45}$$

Equation (44) thus takes two different forms, depending on whether or not the firm is currently in financial distress:

$$\frac{1}{2}\sigma^2 J_{\phi\phi} - rJ - e^{-\gamma c^*(\overline{\phi})} = 0 \qquad \text{if } \phi \geq \phi^*(\overline{\phi}), \tag{46}$$

$$\frac{1}{2}\sigma^2 J^f_{\phi\phi} - rJ^f - e^{-\gamma(\phi - \underline{\phi})} = 0 \qquad \text{otherwise.} \tag{47}$$

The notation J^f is used here to emphasize that J is being calculated when the firm is in financial distress. The general solutions to these p.d.e.s are

$$J(\phi, \overline{\phi}) = A(\overline{\phi})e^{\sqrt{2r}\,\phi/\sigma} + B(\overline{\phi})e^{-\sqrt{2r}\,\phi/\sigma} - \frac{e^{-\gamma c^*(\overline{\phi})}}{r}, \tag{48}$$

$$J^f(\phi, \overline{\phi}) = C(\overline{\phi})e^{\sqrt{2r}\,\phi/\sigma} + F(\overline{\phi})e^{-\sqrt{2r}\,\phi/\sigma} - \frac{e^{-\gamma(\phi - \underline{\phi})}}{r - \frac{\gamma^2\sigma^2}{2}}. \tag{49}$$

To determine the functions A, B, C and F, we need the following boundary conditions. The first boundary condition is

$$J^f(\underline{\phi}, \overline{\phi}) = \int_0^\infty e^{-rt} u(0) dt = -1/r. \tag{50}$$

At the point of financial distress, $\phi^*(\overline{\phi})$, the values and slopes must match, yielding two additional boundary conditions:

$$J(\phi^*(\overline{\phi}), \overline{\phi}) = J^f(\phi^*(\overline{\phi}), \overline{\phi}), \tag{51}$$

$$\left.\frac{\partial}{\partial \phi}\right|_{\phi = \phi^*(\overline{\phi})} J(\phi, \overline{\phi}) = \left.\frac{\partial}{\partial \phi}\right|_{\phi = \phi^*(\overline{\phi})} J^f(\phi, \overline{\phi}). \tag{52}$$

The final boundary conditions are

$$\left.\frac{\partial}{\partial \overline{\phi}}\right|_{\phi = \overline{\phi}} J(\phi, \overline{\phi}) = 0, \tag{53}$$

$$\lim_{\phi \to \infty} J(\phi, \overline{\phi}) = 0. \tag{54}$$

The first of these is analogous to Equation (37), and the second follows from the fact that, when ϕ is very large, so is the manager's compensation, and

$$\lim_{c \to \infty} u(c) = 0.$$

These boundary conditions allow us to solve for the functions $A(\overline{\phi}), B(\overline{\phi}), C(\overline{\phi})$ and $F(\overline{\phi})$:

$$A(\overline{\phi}) = \int_{\overline{\phi}}^{\infty} \frac{\gamma \left(2e^{\frac{\sqrt{2r}u}{\sigma}} - e^{\frac{\sqrt{2r}(\underline{\phi} - c^*(u))}{\sigma}} - e^{\frac{\sqrt{2r}(\underline{\phi} + c^*(u))}{\sigma}} \right) \frac{\partial c^*(u)}{\partial u}}{2e^{c^*(u)\gamma} \left(e^{\frac{2\sqrt{2r}u}{\sigma}} - e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}} \right) r} du, \tag{55}$$

$$B(\overline{\phi}) = \frac{1 - \frac{\sqrt{2r}}{\gamma\sigma} - 2e^{c^*(\overline{\phi})\left(\gamma + \frac{\sqrt{2r}}{\sigma}\right)} + e^{\frac{2\sqrt{2r}c^*(\overline{\phi})}{\sigma}} \left(1 + \frac{\sqrt{2r}}{\gamma\sigma}\right)}{2e^{c^*(\overline{\phi})\gamma - \frac{\sqrt{2r}(\underline{\phi} - c^*(\overline{\phi}))}{\sigma}} r \left(1 - \frac{2r}{\gamma^2\sigma^2}\right)} - e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}} A(\overline{\phi}), \tag{56}$$

$$F(\overline{\phi}) = \frac{\gamma\sigma \left(2\sqrt{2}e^{\frac{\sqrt{2r}\underline{\phi}}{\sigma}}\gamma\sigma + e^{\frac{\sqrt{2r}(\underline{\phi} - c^*(\overline{\phi}))}{\sigma} - c^*(\overline{\phi})\gamma} \left(2\sqrt{r} - \sqrt{2}\gamma\sigma\right) \right)}{2\sqrt{2}r\left(2r - \gamma^2\sigma^2\right)} - e^{\frac{2\sqrt{2r}\underline{\phi}}{\sigma}} A(\overline{\phi}), \tag{57}$$

$$C(\overline{\phi}) = -\frac{e^{-\frac{\sqrt{2r}\,(c^*(\overline{\phi}) + \underline{\phi})}{\sigma}}\gamma\sigma}{2e^{c^*(\overline{\phi})\gamma} r \left(\sqrt{2r} + \gamma\sigma\right)} + A(\overline{\phi}). \tag{58}$$

The final boundary condition, (54), is required to pin down the constant of integration in the expression for $A(\overline{\phi})$. When ϕ goes to infinity, so does $\overline{\phi}$, implying that $\lim_{\overline{\phi} \to \infty} A(\overline{\phi}) = 0$.

Although we do not have an analytic expression for $c^*(u)$, an analytic expression for $\frac{\partial c^*(u)}{\partial u}$ can be derived by first noting that $\Delta(u, D, c^*(u)) = 0$ for any value of u, and then (totally) differentiating this expression with respect to u, and solving for $\frac{\partial c^*(u)}{\partial u}$.

E Calculating Relative Risk Aversion

Recall that J^* is the employee's current level of utility assuming that she is employed under the optimal wage contract with the optimal level of debt. Under the assumption of exponential utility, the certain level payment forever that would provide this level of utility is

$$-\frac{\log(-J^* r)}{\gamma}$$

Wealth, W, is then defined to be the present value of this certain perpetuity (using a discount rate of r):

$$W \equiv -\frac{\log(-J^* r)}{\gamma r}.$$

Multiplying by the coefficient of absolute risk aversion provides a measure of relative risk aversion, RRA:

$$RRA = -\frac{\log(-J^* r)}{r}$$

F Existence and Uniqueness of the Optimal Wage

Proposition 2 and Appendix C define the competitive market wage implicitly via the equation

$$c^*(\overline{\phi}_t) \equiv \left\{ c \,\middle|\, \Delta(\overline{\phi}_t, D, c) = 0, \overline{\phi}_t + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}} \leq c < \overline{\phi}_t + \frac{Dr\tau}{1-\tau} \right\},$$

where

$$\begin{aligned} \Delta(\overline{\phi}, D, c) \;\; \equiv \;\; & \left(2\sqrt{2} \left(\frac{D-K}{1-\tau} \right) r^{3/2} + \left(e^{-\frac{\sqrt{2r}\,c}{\sigma}} - e^{\frac{\sqrt{2r}\,c}{\sigma}} \right) \sigma \right) e^{\frac{\sqrt{2r}\left(\left(\frac{K}{1-\tau} - D\right) r + \overline{\phi}\right)}{\sigma}} - \sigma - \quad (59) \\ & \sqrt{2r} \left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau} \right) + e^{\frac{2\sqrt{2r}\left(\left(\frac{K}{1-\tau} - D\right) r + \overline{\phi}\right)}{\sigma}} \left(\sigma - \sqrt{2r} \left(\overline{\phi} - c + \frac{Dr\tau}{1-\tau} \right) \right). \end{aligned}$$

We here prove that this equation always has a unique solution between $c_{nd} \equiv \overline{\phi} + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}}$ and $c_{full} \equiv \overline{\phi} + \frac{Dr\tau}{1-\tau}$.[22] Note that $c_{full} > c_{nd} > 0$ because of our assumption that

$$\phi_0 > \frac{\sigma}{\sqrt{2r}} - \frac{Dr\tau}{1-\tau},$$

and the fact that $\overline{\phi} \geq \phi_0$. From Equation (59),

$$\Delta\left(c_{nd}\right) = \left[\frac{2\sqrt{2r}(D-K)r}{1-\tau} + \sigma \left(e^{-\frac{\sqrt{2r}c_{nd}}{\sigma}} - e^{\frac{\sqrt{2r}c_{nd}}{\sigma}} \right) \right] e^{\frac{\sqrt{2r}\left(\overline{\phi} - \left(D - \frac{K}{1-\tau}\right) r\right)}{\sigma}} - 2\sigma. \quad (60)$$

Since $D \leq K$, and $e^{-x} - e^{x} < 0$ for all $x > 0$, the term in square brackets is strictly negative, hence $\Delta\left(c_{nd}\right) < 0$. Now consider $\Delta\left(c_{full}\right)$. Define

$$\begin{aligned} x &= \frac{-\sqrt{2r}(D-K)r}{\sigma(1-\tau)}, \\ y &= \frac{\sqrt{2r}c_{full}}{\sigma}, \end{aligned}$$

[22] Appendix G shows that c_{nd} is the optimal wage in the absence of financial distress. Since the possibility of financial distress makes the employee worse off, we are looking for a solution greater than this value. In addition, due to the insurance provided by the firm, the employee cannot be paid more than the full amount of value he is currently adding, c_{full}.

and note that $x, y \geq 0$. We can rewrite Equation (59) as

$$\frac{\Delta\left(c_{full}\right)}{\sigma} = \left(e^{-y} - e^{y} - 2x\right) e^{x+y} + e^{2(x+y)} - 1 \equiv f(x, y). \tag{61}$$

It is immediate that $f(0, y) = 0$ for all y. Now differentiate with respect to x to obtain

$$f_x(x, y) = e^{x+y}\left(2e^{x+y} + e^{-y} - e^{y} - 2x - 2\right) \equiv e^{x+y} g(x, y), \tag{62}$$

and note that f_x and g always have the same sign. When $x = 0$,

$$\begin{aligned} g(0, y) &= 2e^{y} + e^{-y} - e^{y} - 2, \\ &= e^{y} + e^{-y} - 2, \\ &\geq 0 \qquad \text{for all } y. \end{aligned}$$

Differentiating again, we obtain

$$\begin{aligned} g_x(x, y) &= 2e^{x+y} - 2, \\ &\geq 0 \qquad \text{for all } x, y \geq 0. \end{aligned}$$

Since $g(0, y) \geq 0$ and $g_x(x, y) \geq 0$ for all $x \geq 0$, this implies that $g(x, y)$, and hence $f_x(x, y)$, is non-negative for all $x, y \geq 0$. This, combined with the fact that $f(0, y) = 0$ for all y, implies in turn that $f(x, y) \geq 0$ for all $x, y \geq 0$, and hence that

$$\Delta\left(c_{full}\right) \geq 0.$$

Since $\Delta\left(c_{nd}\right) < 0$ and $\Delta\left(c_{full}\right) \geq 0$, by continuity there must be at least one solution to Equation (59) between c_{nd} and c_{full}. To prove uniqueness, note that, if there were more than one solution, there would have to be at least one value of c in this region at which $\Delta'(c) = 0$. But, differentiating Equation (59), the equation $\Delta'(c) = 0$ has exactly two solutions,

$$\begin{aligned} c_{min} &= \underline{\phi} - \overline{\phi}, \\ &\leq 0, \\ &< c_{nd}. \\ c_{max} &= \overline{\phi} - \underline{\phi}, \\ &= \overline{\phi} + \frac{Dr\tau}{1-\tau} + \frac{(K-D)r}{1-\tau}, \\ &\geq c_{full} \end{aligned}$$

Since neither of these values is between c_{nd} and c_{full}, we conclude that there must be exactly one solution to Equation (59) between c_{nd} and c_{full}.

G Solution with no distress

To derive a lower bound on the employee's promised wage, consider a simplified version of the model in which there is no financial distress or bankruptcy; the firm can continue to pay the employee's promised wage, regardless of how low productivity becomes. In this case, given the random walk assumption for ϕ_t, the manager's optimal compensation must be of the form

$$c(\overline{\phi}) = \overline{\phi} + \theta,$$

where θ is some constant (which depends on D and the other parameters of the model). Define

$$x_t \equiv \phi_t - \overline{\phi}_t.$$

By the structure of the optimal contract, for any Δ we have

$$\begin{aligned} V(\phi_t + \Delta, \overline{\phi}_t + \Delta) &= V(\phi_t, \overline{\phi}_t), \\ &= V(\phi_t - \overline{\phi}_t, 0), \\ &\equiv v(x_t). \end{aligned}$$

From Equation (33), V solves the partial differential equation,

$$\frac{1}{2}\sigma^2 V_{\phi\phi} - rV + Kr - Dr(1-\tau) + (\phi - c(\overline{\phi}))(1-\tau) = 0. \tag{63}$$

In terms of x, this becomes the ordinary differential equation,

$$\frac{1}{2}\sigma^2 v_{xx} - rv + (x-\theta)(1-\tau) + Kr - Dr(1-\tau) = 0, \tag{64}$$

the general solution to which is

$$v(x) = Ae^{\sqrt{2r}\,x/\sigma} + Be^{-\sqrt{2r}\,x/\sigma} + \frac{(x-\theta)(1-\tau)}{r} + K - D(1-\tau). \tag{65}$$

For any choice of θ, v must satisfy the two boundary conditions[23]

$$
\begin{aligned}
v'(0) &= 0, && (66)\\
\lim_{x \to -\infty} v'(x) &= \frac{(1-\tau)}{r}. && (67)
\end{aligned}
$$

These imply that

$$
\begin{aligned}
A &= \frac{-\sigma(1-\tau)}{r\sqrt{2r}}, && (68)\\
B &= 0. && (69)
\end{aligned}
$$

To determine θ, note that we must have $v(0) = K - D$, which yields

$$\theta = \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}}. \tag{70}$$

In other words, the optimal compensation contract is to set

$$c(\overline{\phi}) = \overline{\phi} + \frac{Dr\tau}{1-\tau} - \frac{\sigma}{\sqrt{2r}}. \tag{71}$$

[23]The first boundary condition is a consequence of x_t possessing an upper reflecting boundary at 0 (see Dumas (1991)). The second boundary condition applies because, for very low x, hitting the upper boundary is irrelevant. Thus, an increase of $1 in x today results in a permanent increase of $\$(1-\tau)$ in the dividend, with a present value of $(1-\tau)/r$.

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